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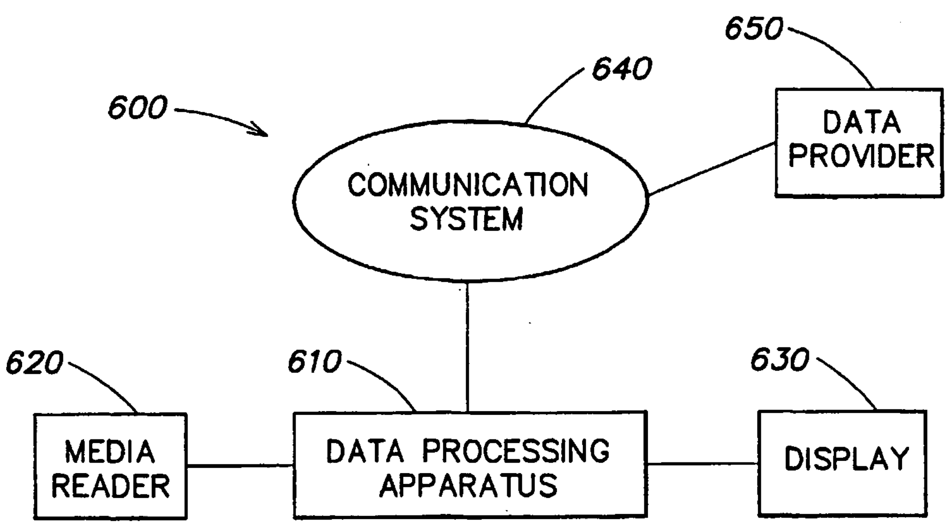
(54) **Title:** METHOD AND APPARATUS FOR CONTROLLING ACCESS TO STORAGE MEDIA



(57) **Abstract:** A method and apparatus for preventing copying of data from optical storage media. A locus on optical storage medium is initially read to produce a signal and is then re-read by a reader to produce a second signal. The signal detected upon re-reading is different from the signal that is detected upon initial sampling. A method and apparatus for controlling access to a storage medium, such as an optically readable medium. Light sensitive or other materials that are adapted to change state and affect reading of a storage medium are used to control access to data that may be stored on optical medium and/or to control use of the medium.

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METHOD AND APPARATUS FOR CONTROLLING ACCESS TO STORAGE MEDIA

Field of the Invention

The present invention is directed to controlling access to storage media, such as data recorded on optical media, and copy protection of optical recording media and specifically to the protection of data recorded on optical disks.

Background of the Invention

Optically readable storage media, such as music and software CDs and video DVDs, provide inexpensive ways to share and disseminate digital information, making such media the media of choice among both producers and consumers. This is clearly evident as CDs have nearly replaced cassette tapes and floppy disks in the music and software industries and DVDs have made significant inroads in replacing video cassette tapes in the home video industry. Because of the high demand for such optical media and because of the ease and low cost of reproduction, counterfeiting has become prevalent.

A variety of copy protection techniques and devices have been developed to limit the unauthorized copying of optical media. Among these techniques are analog Colorstripe Protection System (CPS), CGMS, Content Scrambling System (CSS) and Digital Copy Protection System (DCPS). Analog CPS (also known as Macrovision) provides a method for protecting videotapes as well as DVDs. The implementation of Analog CPS, however, may require the installation of circuitry in every player used to read the media. Typically, when a disk or tape is "Macrovision Protected," the electronic circuit sends a colorburst signal to the composite video and s-video outputs of the player resulting in imperfect copies. The use of Macrovision may also adversely affect normal playback quality.

With CGMS, the media may contain information dictating whether or not the contents of the media can be copied. The device that is being used to copy the media must be equipped to recognize the CGMS signal and also must respect the signal in order to prevent copying. The Content Scrambling System (CSS) may provide an encryption technique that is designed to prevent direct, bit-to-bit copying. Each disk player that incorporates CSS is provided with one of four hundred keys that allow the player to read the data on the media, but prevents the copying of the keys needed to decrypt the data. However, the CSS algorithm has been broken

and has been disseminated over the Internet, allowing unscrupulous copyists to produce copies of encrypted disks.

The Digital Copy Protection System (DCPS) provides a method whereby devices that are capable of copying digital media may only copy disks that are marked as copyable. Thus, the disk itself may be designated as uncopyable. However, for the system to be useful, the copying device must include the software that respects the "no copy" designation.

Each of these copy protection techniques, and others that may be available, may make it more difficult to copy material from optical media, and may deter the casual copyist. However, these techniques may be easily circumvented by the unscrupulous copyist who is intent on making digital copies of a disk.

In addition to directly copying content from optical media, producers and distributors of digital content are also adversely affected by unauthorized distribution of content over communications systems, such as the Internet. Known copy protection systems may not be capable of protecting a digital data file from being duplicated if it is intercepted by a copyist during transmission over these communication systems.

Summary of the Invention

In one illustrative embodiment, a method of authenticating optical storage media is disclosed. A locus on an optical storage medium is read and a first set of data is received from the locus. The locus is then re-read and a second set of data is read from the locus, the second set of data being different from the first set of data.

In another illustrative embodiment an optical disk is disclosed. The optical disk includes a substrate and a data track disposed on the substrate. A light-sensitive compound is disposed on at least a portion of the disk and cooperates with the data track to alter the data upon excitation with a suitable stimulus.

In another illustrative embodiment, a method of treating an optical storage medium is disclosed. Data is recorded onto the optical storage medium and a light-sensitive compound is applied to the medium. At least a portion of the light-sensitive compound is selectively activated.

In another illustrative embodiment an optical recording medium is disclosed. The optical recording medium includes stored data and means for altering, upon re-reading, data that is read from a locus on the medium.

In another illustrative embodiment, an optical recording medium is disclosed. The medium include a data track including readable data. At least a portion of the output is altered predictably upon re-reading.

In another illustrative embodiment, a method of authenticating an optical storage medium is disclosed. The medium has a first plane including data and a second plane having a light-sensitive compound. The method includes reading data from the first plane, exciting the light-sensitive compound in a second plane and reading data from the second plane.

Embodiments of the invention enable control of access to storage media, such as optical disks. A material may be provided on the media that is alterable between at least two states, wherein at least one of the states affects whether or how data is read from the media. The material may represent information, such as a conventional barcode represents information on a package, or an encryption/decryption key, or the presence of the material alone may allow access to the media. The material may prevent reading data from a medium, or alter a result of reading data from a medium, e.g., while the material is in one state a data bit "1" may be read, but while the material is in another state a data bit of "0" may be read. The material may be permanent to allow authorized access to the medium for its normal expected lifetime, or temporary such that the material prevents access to the medium when it is no longer detectable after a certain amount of time or a number of reads of the medium.

Aspects of the invention may also provide for secure downloads of data as well as provide for "uncopyable copies" of data that has been legitimately downloaded from a source. Aspects of the invention may be used to limit the number of times software may be installed or the location of the installation of software. The material may be used to provide dynamic watermarking of data, or used to uniquely identify a specific storage medium.

In another aspect of the invention, an optical media may include a light sensitive material that is positioned in or on the medium so that it provides a code that may be required to install software from the medium onto a computer. For example, the code provided by the pattern of light sensitive material on the medium may be required to match a code that is input by the user of the medium in order for the software contained on the medium to be properly installed.

In another aspect of the invention, a particular medium, for example a CD or a DVD, may be provided with an invisible authentication mark or code in the form of a pattern of light sensitive material. The pattern of light sensitive material that has been placed in or on the medium may be verified by an optical reader prior to allowing the medium to be used for either reading or recording digital data. The medium may include, for example, a phosphorescent dye placed in or on the surface of the medium, and the material may not respond instantaneously to excitation by light of a particular wavelength. However, the material may provide a delayed, persistent response that can be detected upon a later reading.

In another aspect of the invention, an optical medium, for example a CD or a DVD, is provided with a data track that is recorded onto the medium using a temporary light sensitive material. The temporary light sensitive material may allow for a limited number of uses of the data contained in the medium prior to its fading and providing inadequate data to allow the medium to function as originally intended.

In another aspect of the present invention, software may be distributed on a medium that includes a light sensitive material that provides a code allowing the user of the medium to access a portion of the data contained on the medium. For example, the medium may include a version of software that can be freely used and copied to other recording devices. However, to access an advanced program recorded on the medium, a code represented by the pattern of light sensitive material contained in or on the medium must first be detected on the medium itself.

In another aspect of the invention, an optical medium containing a pattern of light sensitive material may be placed in a reader attached to a computer where the pattern of light sensitive material may be detected. A data file, for example a movie or audio file, may then be downloaded from a network to the computer in a form that is unplayable in the absence of the code provided by the light sensitive material on the medium. This may allow for the download of digital files such as movies, over the Internet, that result in playable copies only when recorded onto media that contain the proper sequence of light sensitive material in or on the medium. The system may, for example, prevent the downloading of a digital data file without a properly encoded disk, or in another embodiment, may result in an unplayable copy if not downloaded onto an appropriate disk.

In one embodiment, optical media may include a light sensitive material in addition to any recording layer, such as a data track. The recording layer may be used to record data that

may be read from the media to perform a function for which the media is distributed. For example, the media may include a software program recorded on a data track to be used with a personal computer. The light sensitive material may be placed in one or more loci on the media and may or may not represent data that is read from the media when the software is installed.

In another embodiment, the light sensitive material may be used to complete an incomplete data set. For example, a data file may be recorded on a medium so that it includes less than what is necessary to make the data file operable. Enough data may be missing so that error correction techniques may be ineffective. However, the missing data may be provided in the form of, for example, a light sensitive material strategically placed on the medium or on a companion medium. Both data sets may then be combined to result in an operable disk. The entire process may be transparent to the user. Instructions for reading the missing data may be provided, for example, in software contained on the medium, in firmware, in hardware or in instructions provided by the user. Thus, any copy of the medium may be inoperable absent either the strategically placed light sensitive material or the instructions on how to access the light sensitive material.

In another embodiment, access, copying and unauthorized installation of digital data may be prevented by placing light sensitive material in the light path of the reader so that the light sensitive compound interferes with the reading of the underlying data. For example, instructions provided to authorized users of a software program may instruct an installation program to read a specific track and then to wait a specified time to access an adjacent track. Absent these instructions, a light sensitive material will have been activated upon reading the first track and will interfere with the reading of adjacent, or nearby, tracks, for a period of time equal to the time of persistence of the light sensitive material. Thus, authentic reading or installation instructions will provide a map for avoiding these traps. Areas of light sensitive material may be large enough to defeat sophisticated error correction programs, such as EFM and parity bit correction techniques known to those of skill in the art.

The light sensitive material may be placed at a position or a number of positions on the optical medium in order to provide, for example, identification, verification, an access code or additional data. In one embodiment, the light emissive compound may be deposited in or on the optical medium in order to identify the medium or supply information about it, much like a bar code may be used to identify a product or package. For example, the medium may be

theoretically divided into a number of sectors, for instance, 20 pie shaped pieces of equal size around a circular optical recording medium such as a CD-ROM or DVD. Depending on where light sensitive material is placed in each of these sectors, digital data may be represented by either the absence or presence of light sensitive material at different locations in each sector. Sampling instructions may be supplied through a number of channels. For example, instructions may be supplied on the medium itself, by the optical reader or by the user of the device. The sampling instructions may direct the reader to sample various locations within each sector looking for the presence or absence of light sensitive material. In addition, the reader may be instructed to sample at a specific time delay or to look for a shift in wavelength from that provided by the light source. Thus, each sector may provide information that may not be detected unless specifics such as position, wavelength, time of delay and persistence of the light sensitive material are known. A number of different materials having different characteristics may be used on a single medium to provide a more sophisticated coding technique.

Light sensitive material may be placed on a medium in a pattern that provides a code to unlock access to data stored on the medium, or elsewhere, such as from an attached data storage device. Thus, the coded optical medium may be used as an uncopyable key to provide access to data, files and information. The light sensitive material may be placed on the medium so that, upon reading, a unique data string is produced that allows the data files to be opened. The data string may be a function of, for example, emission, absorption, wavelength shift, time delay, persistence or intensity of the light sensitive material. Thus, a wide variety of variables may be used with a single medium to provide a sophisticated code. For example, an unscrupulous copyist may try to decode a medium by determining where on the medium delayed emission compounds have been placed. However, other variables such as absorbing compounds, compounds exhibiting different persistence, and compounds emitting at different intensities may be used to further thwart the copyist. Alternatively, the code may be simple, such as the placement of a single spot of light sensitive material on the medium.

These and other aspects of the invention will be apparent from the following description.

Brief Description of the Drawings

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration of one type of optical reader that may be used with an embodiment of the present invention.

Figure 2 is an enlarged cross-sectional illustration of an optically readable medium including recorded data.

Figure 3 is a cross-sectional illustration of an optically readable medium including recorded data and a representation of the binary data that is read when the medium is sampled.

Figure 4 is a cross-sectional illustration of an optically readable medium including recorded data and a representation of the binary data that is detected when the medium is sampled.

Figure 5 is a cross-sectional illustration of the optical medium of Figure 4 including a representation of the binary data that is read when the medium is re-read.

Figure 6 is a cross-sectional illustration of an optical medium including a representation of binary data that is detected when the medium is re-read.

Figure 7 is a schematic block diagram of a system that may be used with the present invention.

Figure 8 shows an optical medium having light sensitive material positioned in or on the medium.

Figure 9 shows a portion of an optical medium having a spot of light sensitive material associated with four data tracks.

Detailed Description

One aspect of the present invention is directed to protecting optically recorded media from being reproduced or copied. This aspect provides for the altering of the digital data output from a section of the media in a manner that allows the data to be read without requiring alterations to the hardware, firmware or software used in optical media readers while preventing reproduction of the medium. This may be accomplished by employing a light-sensitive compound on the disk that reacts upon excitation from the light within a conventional optical reader in a manner to selectively alter data read by the reader.

Another aspect of the present invention relates to controlling access to a storage medium, such as an optical disk. Aspects of the invention provide for copy protection as well as identification and use, such as writing data, of a storage medium, and/or encryption, distribution

protection, or other use of data associated with a storage medium. For example, one aspect of the invention provides a method and apparatus for preventing the unauthorized reproduction of data recorded on an optical medium as well as limiting the distribution of data that may be distributed over a communications system, such as the Internet. Aspects of the invention may be practiced without alterations to readers and writers that are currently used with optical media such as CD-ROMs, Audio CDs, MO disks, and DVDs.

As one example, a CD may include a light sensitive material that is positioned in one or more positions on the CD. The light sensitive material may be alterable between two states, such as transparent and light emitting, to affect reading of data from the CD. The light sensitive material may be caused to change from a first state to a second state by being illuminated, such as by laser light from a CD reader, and then change from the second state to the first state without being illuminated. The light sensitive material may have some delay time between being illuminated and actually changing from the first to second state, e.g., changing from transparent to light emitting, so that data may be read from the CD before the light sensitive material changes to the second state. Thus, the delay time of the light sensitive material may be made longer than the read time (including oversampling) for a portion of the CD. Once the light sensitive material has changed to the second state, the material may remain in the second state, or have some persistence, for some time period, e.g., may remain light emitting for 1ms or more. While the material is in the second state, the material may affect whether and how the CD is read, e.g., the material in the light emitting state may cause the reader to output a string of "0"s rather than output actual data positioned on the CD below the material, or may cause the reader to be unable to read the CD.

The light sensitive material may be used to verify that the CD is authentic, e.g., was obtained from a particular source and/or includes data authorized for particular use. For example, detection of the light sensitive material adjusting from a first transparent state to a second light emitting state after being exposed to light, such as laser light from a CD reader, may be used to perform an authentication test on the CD. The authentication test may include initially scanning the CD for light emitting regions (which are not found initially since the light sensitive material had not been exposed to light cause a change in state) followed by a subsequent scan for light emitting regions (which results in locating at least one light emitting region of light sensitive material that changed state in response to being exposed to light in the

initial scan). Identifying a region of the CD that did not exhibit light emitting portion during an initial scan followed by identification of a light emitting portion in the region during a subsequent scan may be used to determine that the CD is authentic.

The above descriptions are exemplary and other aspects of the invention are described below. For example, the light sensitive material may be alterable between states other than transparent and light emitting, such as invisible and visible, light transmissive and light absorbing, light emitting and non-emitting, and so on. The light sensitive material may be positioned on an optical medium to provide information, such as a code (like a barcode), actual readable data, and so on, or prevent sequential access to data on the medium, rather than only being detectable within specific regions. Thus, the light sensitive material may be used as part of a data encryption, watermarking or other protection scheme, in addition to providing an authentication feature.

The following definitions, without limitation, may be used.

"Optical Recording Medium" refers to a medium capable of recording digital data that may be read by an optical reader.

"Optical Storage Medium" refers to a medium capable of storing digital data that may be read by an optical reader.

"Light Sensitive Material" refers to a material that is alterable between at least two states when irradiated with light.

"Light Sensitive Compound" refers to a compound that responds to irradiation with light.

"Light Absorptive Compound" refers to a compound that absorbs light in response to excitation.

"Light Emissive Compound" refers to a compound that emits light in response to excitation.

"Authentication Material" refers to a material used to authenticate, identify or protect an optical medium. The data recorded on an optical medium, for example, software, video or audio files, are not authentication material.

"Temporary Material" refers to material that is detectable for a limited amount of time or a limited number of readings.

"Re-read" refers to reading a portion of the data recorded on a medium after it has been initially read.

"Fluorescent Compound" refers to a compound that radiates light in response to excitation by electromagnetic radiation.

"Phosphorescent Compound" refers to a compound that emits light in response to excitation by electromagnetic radiation wherein the emission is delayed or persists from the time of excitation.

"Recording Layer" refers to a section of an optical medium where data is recorded for reading, playing or uploading to a computer. Such data may include software programs, software data, audio files and video files.

"Recording Dye" refers to a chemical compound that may be used with an optical recording medium to record digital data on the recording layer.

"Security Dye" refers to a compound that may provide or alter a signal to protect the data on a storage medium.

"Active Light-Sensitive Compound" refers to an active form of a light-sensitive compound, as some light-sensitive compounds may exist in both active and inactive states.

"Active Security Dye" refers to the active form of a security dye, as some security dyes may exist in both active and inactive states.

"Activate" refers to transforming a compound from an inactive to an active state.

"Non-Destructive Security Dye" refers to a security dye that does not render optical media permanently unreadable.

"Reader" refers to any device capable of detecting data that has been recorded on an optical medium. Examples are CD and DVD readers.

"Communication System" refers to any system or network for transferring digital data from a source to a target.

Copy protection schemes that are available today typically require changes to the hardware that is used to read, and potentially copy, the media, or these schemes require the use of data encryption that may be broken by those who are determined to do so. Aspects of the present invention may provide a technique that requires neither encryption nor hardware changes but may incorporate a physical change in the media itself. Aspects of the invention may provide for a first data set when the media is sampled by a reader and then may provide for an alternative data set when the media is re-read by the reader.

In one aspect of the invention, a specific locus on an optical storage medium is read, and the same locus is re-read again. Upon re-reading, the data that is read from the locus is different from that of the initial reading. This may be accomplished by incorporating a compound into or onto the media. Upon exposure to light of a wavelength, the compound may provide no immediate response. However, upon re-reading by the reader, which occurs later in time, the compound emits light at an intensity and wavelength sufficient to alter the data that is read from the media. In one aspect, as will become apparent, the data is blocked upon re-reading.

In another aspect, an optical disk that includes a substrate with a data track disposed on the substrate includes a non-destructive light-sensitive compound that has been disposed on at least a portion of the disk.

In another aspect of the invention, a light-sensitive compound is applied to an optical storage medium on which data has been or will be recorded. At least one portion of the light-sensitive compound may then be selectively activated so that the light-sensitive compound provides delayed light emission or absorption in response to excitation with a light source.

In another aspect, a method of authenticating optical storage media is provided wherein data is sampled from a first track of an optical medium with the first track being located in a first plane, and at the same time, exciting a light-sensitive compound that resides in a different, second plane on the optical medium. The output produced from the light-sensitive compound in the second plane is then sampled from the optical medium.

In another aspect, a data track containing readable data is re-read and at least a portion of the data is predictably altered upon re-reading.

The invention may be useable with conventional optical media. For example, a CD or DVD disk incorporating the invention may provide protection when being read by an "off the shelf" CD or DVD player. In addition, the invention may be incorporated into mass production techniques that are currently used to produce, for example, CDs and DVDs, and may not require changes to production line plant and equipment. Figure 1 provides a schematic representation of a conventional CD or DVD reader that may be used in conjunction with the invention.

Referring to Figure 1, a light source 10, typically a laser diode, emits light of a specific wavelength, for example, 780 nm. The light passes through defraction grating 20 where it splits into a primary beam 30 and secondary beams 31 and 32. Each of these beams then passes through polarizing beam splitter 40 which polarizes them by 90 degrees. Each of these beams

then passes through collimating lens 50 and then through ¼ waveplate 60. ¼ waveplate 60 converts the light into circularly polarized light. The polarized, collimated light beams then pass through objective lens 70 and are focused onto optical disk 80, such as a CD or DVD, that is spinning at a variable rate to provide for constant velocity of the track, regardless of the laser's position on the disk. Any light that is reflected back from the disk (see description below) passes back through the objective lens 70 and through the ¼ waveplate 60 which further polarizes the light so that it is now polarized perpendicularly in comparison to the polarization of the first light beam prior to its initial passage through the ¼ waveplate 60. The reflected beam then passes back through the collimating lens 50 and because of its change in polarization is now reflected off of beam splitter 40 rather than passing through beam splitter 40. The reflected beam is then focused through concave lens 90 and further through cylindrical lens 100, which aids in the tracking of the light beam along the data track. Finally, the reflected light beam impinges upon photodetector 110 where the signal can be detected and processed.

Although one type of optical reader is described, the present invention is not limited in this respect and other suitable optical readers may be employed in conjunction with the invention. The above description, therefore, is merely illustrative of a typical optical reader. Those skilled in the art will recognize various alternatives for an optical detector, whether embodying some or all of the elements described above, that may be employed with the present invention.

An enlarged view of the CD 200 is illustrated in Figure 2, which shows a cross-sectional view (not to scale) of a track on the CD. The CD substrate 210 is typically made from a polymer such as polycarbonate, however, other suitable materials may be used. Data is recorded on the CD by forming a series of pits 220 and lands 230 in the substrate of the disk. Pits and lands may be formed using any suitable technique including injection molding of the features themselves or, alternatively, using a recording compound and a writing laser. If a recording compound is used, data may be written to the medium using a laser that is designed to heat the recording compound to a point where adjacent polymer material is deformed to form the pits and lands. Typically, for an audio CD, each pit is about ½ micron wide and anywhere from about 0.8 to 3.5 microns long. However, it should be appreciated that the present invention is not limited in this respect and other methods of recording and /or sharing data on the CD may be employed.

The pits and lands are typically coated with a reflective layer 240, of, for example, aluminum, which is then coated by a protective layer 235, typically acrylic. If desired, the acrylic layer may be covered by a label, 250. In operation, the light beam 260, typically at a wavelength of 780 nm, passes through the surface of the polycarbonate substrate 210 where it becomes more sharply focused due to the high refractive index of the polycarbonate. The high refractive index may also alter the wavelength of the light, for example, from 780 nm (infrared) to about 500 nm (green). The beam is focused on the reflective surface 240 where it is highly reflected by the lands 230, and less directly reflected, or scattered, by pits 220. The pits are typically formed at a height of about ¼ of the wavelength of the light passing through the polycarbonate. Thus, light that is reflected from a land travels about ½ wavelength farther than light that is reflected from a pit, resulting in light reflected from a pit being out of phase with light reflected from a land. The two waves will therefore cancel each other, resulting in no light being reflected back to the detector.

Figure 3 illustrates schematically one method of transforming a light beam reflected off of a CD into digital information. By setting a threshold level of reflectance, transitions between pits and lands may be detected at the point where the signal generated from the reflectance crosses a threshold level. Whenever the threshold level is crossed, i.e., a transition between a pit and a land or between a land and a pit is detected, a binary code of 1 is read. At all other intervals, a 0 is detected. Thus, both pits and lands may actually represent a series of 0's; it is the transition that represents a 1. In this manner, binary information may be read from the disk.

As may be apparent to those skilled in the art, the data on a disk may be transformed using an eight to fourteen modulation (EFM) convention. EFM provides a process whereby 1's need not be written consecutively, as this would require extremely small pits or lands with frequent transitions that might result in numerous errors. In addition, EFM specifies that at least two and no more than 10 0's appear between any pair of 1's. In addition, three merging bits are placed between each fourteen bit set to help further minimize errors. After detection, each fourteen bit piece of data is converted into an eight bit binary word. The fourteen bit process that is physically recorded onto the optical medium may contain no more than ten and no fewer than two 0's between each pair of 1's, but can represent any eight bit word. Although an EFM protocol has been described, the present invention is not limited in this respect and other protocols may be implemented. In addition, no such protocol need be employed. Thus, the

above-described EFM is merely illustrative of conventional manipulation of data combined on a CD.

Figure 3 shows how the raw bit data may be read from a CD track as it passes under the light source. For example, referring again to Figure 3, transition points may be seen at points A, B, C and D. Each of these points corresponds to a transition in the medium between a pit and a land or a land and a pit. At each of these transition points, the signal generated from the reflected laser crosses the threshold and a 1 is read at each of these transition points. At non-transition points, a series of 0's is read.

Although the above Figures are described with reference to a CD, certain or all aspects of such a description may apply to other optical media, such as DVDs.

The method and apparatus of the present invention may provide producers and distributors of digital data with a technique that aids in the prevention of reproducing, for example, software, audio and video optical media. Some of the formats with which the invention may be useful include, but are not limited to, CD Audio, CD-ROM, CD-G, CD-i, CD-MO, CD-R, CD-RW, DVD, DVD-5, DVD-9, DVD-10, DVD-18 and DVD-ROM.

In one embodiment, the invention may provide copy protection by changing the output from an optical medium upon re-reading of a locus on the medium. The location that is re-read may be of any size or type and may include, for example, a single bit, a byte, a frame, a block, a sector or any other selection that is recorded or will be recorded on the medium. In addition, any number of different locations may provide a change in output upon re-reading.

Many conventional optical media readers such as CD and DVD readers may be capable of oversampling a particular locus on the optical medium to reduce the likelihood of playback errors. Oversampling may occur immediately after an initial sampling or may be delayed. Software written on the optical medium may direct the reader to resample a particular set of data one or more times, or a reader may be pre-programmed to resample the media a number of times without any additional input from software on the media. For example, one way in that a CD player may resample data is by oversampling an audio disk several times in order to reduce errors and ensure adequate reproduction. A data set on a CD or DVD may be oversampled any number of times, for example, 4X or 8X, and the readings may be compared so that errors may be eliminated or minimized. In one embodiment, the invention may incorporate such oversampling.

The output at a particular locus may be changed by including an additional compound in the medium. For example, on an initial reading, the compound may have little or no effect on passing light and therefore underlying data is read and interpreted as originally recorded. However the passing light may influence the compound and change its properties so that upon re-reading, the signal that is received by the detector is different from that which was received upon initial sampling. The compound may be a light sensitive compound. For instance, the added compound in the medium may become reflective within a timeframe that provides for reflectance of the light beam upon resampling. Alternatively, a compound may provide for delayed emission or absorbance of light and therefore may be used to alter the signal either positively or negatively.

In one example, data recorded on an optical medium instructs the optical reader to re-read a particular locus on the medium. For example, the reader may be instructed to re-read a sector on the disk. The medium may contain areas that include a light sensitive compound, such as a fluorescent or phosphorescent compound. This light-sensitive compound may be chosen so that it is excited by a wavelength that is typically used by a reader on which the particular medium is played. For example, in the case of a CD reader, the light-sensitive compound may be chosen to absorb at about 780 nm. The light-sensitive compound may be placed anywhere in or on the medium and in one aspect may be strategically placed in the light path between the data recorded on the optical medium and the detector that is used to read the reflected light off of the medium. If, upon re-reading, a reading from the light-sensitive compound is detected, access to the data on the media may be provided. If the response upon re-reading is the same as upon initial sampling, indicating absence of the light-sensitive compound, further access may be denied.

Protection may be also provided by using a light-sensitive compound to record data at a particular locus required for the optical media to be operable. The light-sensitive compound may be placed in a different plane in the media, so that in order to be optimally read, the focal length of the optical system should be adjusted. Software included on the disk may direct the optical reader to alter its focal length appropriately, however, when an attempt is made to reproduce the media, the copyist may be unable to reproduce the required data on media that does not include properly placed light-sensitive compound.

The light-sensitive compound may be placed in the medium as close to the recorded data as possible. This may provide, for example, a more precise focusing of the light beam in the area of the light-sensitive compound as the substrate material of which the medium is composed may serve as a lens to further concentrate the light beam at the point where the data has been recorded. Thus, if the light beam focuses on the appropriate plane in which the recorded data lies, it may not be fully focused on the light-sensitive compound that lies in a plane that is a distance from the recorded data. To minimize this difference in focal length, the light-sensitive compound layer may be placed directly over or under or both over and under the recorded data. Upon a first pass of the light beam over the locus of the medium containing the light-sensitive compound, the compound may absorb some of the light, however, some of the light may pass through the compound striking the recorded data on a track in the medium, and reflecting back up through the light-sensitive compound to a detector where the data may be read, as it would be in the absence of the light-sensitive compound. However, if the reader has been instructed to re-read this particular locus, the reader will return to the same area on the medium in order to re-read the same set of data. By this time however, the light-sensitive compound may be emitting or reflecting or absorbing at a wavelength detected by the reader, and the signal produced from the detector may differ from that produced upon initial sampling, as areas that were initially of low reflectance, e.g., pits in the recording medium, are now read as reflectant due to the emission from the light-sensitive compound. If the emission from the light-sensitive compound is sufficient to provide a signal above a threshold, the data output will be varied from that which was originally read upon initial sampling. Thus, at the same point on the track, the recorded data may be read differently, though predictably, depending on whether the data is being initially read or re-read.

Protection may also be implemented by changing the wavelength of light from a reader. For example, the recorded data on the media may include instructions for the reader to use a different light source having a different wavelength to sample a particular locus on the medium. If the proper light-sensitive compound is present at the proper location, it will provide a detectable signal in response to being irradiated with light of the different wavelength. In turn, this may allow for continued access to the disk. If there is no response at the different wavelength, then access may be denied.

In another embodiment, delayed fluorescent compounds or phosphorescent compounds, emitting at a detectable wavelength after a specific amount of time, may be used in combination with an instruction set recorded on the medium that instructs the reader to re-read a specific locus on the medium after a time delay approximately equal to the amount of time required for the light-sensitive compound to fluoresce. For example, if a light-sensitive compound exhibits a peak fluorescence 1 millisecond after excitation by the light source, the medium may include instructions to direct the reader to re-read the particular area of the medium after a 1 millisecond time period. If, at the 1 millisecond time period, the expected fluorescence signal is detected, the reader is instructed to continue reading the recorded data off of the medium. If the expected fluorescence is not detected, access to the data on the disk may be denied. In this manner, a medium that does not include the proper compound in the proper location may not provide usable data to someone trying to access the data on the medium. Therefore, if an attempt is made to copy the optical medium, for example, by bit to bit copying, much of the data that is recorded on the medium may be successfully transferred, however the light-sensitive compound may not be copied as it may only be activated upon re-reading and in a typical bit-to-bit copying utility, bits are systematically copied as they are read. Thus, the copy will be inoperable.

The present invention is not limited to any particular time delay as any material exhibiting a suitable time delay may be used. Thus, a time delay ranging from as little as one millisecond to twenty minutes or more may be employed.

Furthermore, if the light-sensitive compound is, in fact, detected during the copying procedure, it may not be possible to reproduce the signal provided by the light-sensitive compound at the same location on the optical medium that holds the originally recorded data, as a single locus on a track cannot simultaneously hold two different data sets. Therefore, when an attempt is made to operate a copy of the medium, the reader will be instructed to initially sample a specific locus on the medium and then re-read the locus looking for a different response. The unauthorized copy, however, may be able to provide only one of the two required responses as the copying system may be capable only of writing a single data set to the specific locus on the medium. Even if the data represented by the light-sensitive compound is copied, it may not be copied to the correct location and thus the copy may remain inoperable.

In other embodiments, any combination of sampling and re-reading of one or more areas of the medium may be employed. For example, the reader may be directed to resample a

location on the medium and then wait a sufficient time for fluorescence to degrade to nondetectable levels and then take a sampling of the location and detect the signal received from the underlying data.

In another embodiment, the reader itself may be programmed or designed to resample and analyze specific areas on an optical medium prior to proceeding with reading the medium. In this manner, among others, it may be possible to copy protect the optically readable medium without including reading instructions on the medium itself.

In addition to using fluorescent light-sensitive compounds, other light-sensitive compounds, for example, dyes, pigments, phosphorescent compounds and light absorptive compounds may also be employed. For example, light absorptive compounds may be used to selectively absorb light that may be emitted by a reader or reflected off of particular areas of the medium. In this manner, the invention may allow a signal from a specific locus on a medium to be altered from one giving a reading above a threshold to one that reads below a threshold. Thus, the invention may be used to supply a positive signal where previously a negative one was present or alternatively, to supply a negative signal where previously a positive one was present. Various combinations of compounds may be used on the same or different media to produce both positive and negative changes in signal upon re-reading.

Light-sensitive compounds may be placed on the optical media in a number of ways. For example, a compound may be specifically placed in the optical path between a data set that has been recorded on the medium and the optical detector. It may be appropriate to place a light-sensitive compound over (or under or both over and under) a larger area of the media than is necessary to provide a signal change. As it may be preferable for the light-sensitive compound to be active only upon re-reading, extraneous placement of the compound may not interfere with the initial reading of the recorded data. Furthermore, the light-sensitive compound may be distributed on the media in an inactive form and specific areas containing the compound may be activated later in time. For example, an inactive form of a delayed fluorescence compound may be spin coated across a portion of, or all of, the media. After the inactive form of the fluorescent compound has coated a portion of the media, it may be selectively activated at one or more locations to transform the compound into an active form.

In one embodiment, specific areas of the fluorescent compound may be activated by crosslinking. For some light-sensitive compounds, a laser may catalyze crosslinking of the

inactive form of the light-sensitive compound and thus selectively transform it into an active form. This technique may allow for localized compound activation and may provide for data alteration on a small scale, such as a single bit. This selective activation of various portions of the light-sensitive compound may be performed in a manner similar to that used to write data to a CD-R disk. In fact, the same device may be used to write data to a disk as well as to selectively activate portions of the light-sensitive compound. This may be done, for example, by using a variable power writer, or alternatively, it may be done by placing the light-sensitive compound on the disk in a plane that provides a different focal point than that provided by the recording dye. In this latter method, the focal point of the writing laser may then be altered to either affect the recording dye or the light-sensitive compound. If the data track on a specific medium is transferred to the medium by a physical means, for example, by injection molding, the activation wavelength of the light-sensitive compound may be chosen without regard to recording dyes.

In another embodiment, the light-sensitive compounds may be chosen from those having an excitation wavelength at or about the same wavelength used by a reader. For example, if a CD reader uses a laser diode emitting light at a wavelength of about 770-830 nm, then the light-sensitive compound may be chosen from a group having excitation wavelengths in the same range. In another embodiment, the light-sensitive compound may be chosen from a group of compounds having excitation wavelengths at about 630-650 nm, a wavelength typically used in a DVD reader. In another embodiment, compounds may be chosen that possess dual excitation wavelengths at both about 780 nm and about 530 nm. If such a dual wavelength compound is used, a single compound composition may be employed for use with media to be used with either a CD player or a DVD player. Such a compound composition may be either a mixture of different compounds or contain a single compound that exhibits multiple excitation wavelengths.

In another aspect, the compounds are chosen so that they emit at wavelengths that are the same or close to the same as the wavelengths that are detected by the readers. For example, for use with a CD, the light-sensitive compound may emit at about 780 nm and for use with a DVD, the light-sensitive compound may emit at a wavelength of about 650 nm. The chosen security dies may exhibit long term stability under typical optical media storage conditions and the compounds may be light fast and non-reactive. In addition, compounds may be chosen based on

compatibility with the polymer or other material that is used to produce the optical media substrate. Light-sensitive compounds may be chosen from those that exhibit stability for the expected lifetime of the optical media.

In one embodiment, the light-sensitive compounds are chosen from a group of dyes, specifically, cyanine dyes. These cyanine dyes include, among others, indodicarbocyanines (INCY), benzindodicarbocyanines (BINCY), and hybrids that include both an INCY and a BINCY. Hybrids may be, for example, mixtures of two different dyes or, in another embodiment, compounds that include both INCY and BINCY moieties. In one embodiment, the light-sensitive compound is a ratiometric compound having a linked structure with excitation ranges at both the CD and DVD ranges of about 530 and 780 nm. In a further embodiment, the dye is phosphorescent, having a time delay of about 10 milliseconds. The present invention is not limited to any particular compound and any suitable compound emitting light of any suitable wavelength may be used. For example, single or multiple compounds each having one or more emission wavelengths from about 400 nm to about 900 nm may be used. Table 1 provides some of the dyes that may be useful with the invention.

Table 1

Dye Name/No.	CD/DVD	Excitation wavelength	Emission wavelength
Alcian Blue (Dye 73)	DVD	630 nm	Absorbs
Methyl Green (Dye 79)	DVD	630 nm	Absorbs
Methylene Blue (Dye 78)	DVD	661 nm	Absorbs
Indocyanine Green (Dye 77)	CD	775 nm	818 nm
Copper Phthalocyanine (Dye 75)	CD	795 nm	Absorbs
IR 140 (Dye 53)	CD	823 nm (66 ps)	838 nm
IR –768 Perchlorate (Dye 54)	CD	760 nm	786 nm
IR 780 Iodide (Dye 55)	CD	780 nm	804 nm
IR 780 Perchlorate (Dye 56)	CD	780 nm	804 nm
IR 786 Iodide (Dye 57)	CD	775 nm	797 nm
IR 768 Perchlorate (Dye 58)	CD	770 nm	796 nm
IR 792 Perchlorate (Dye 59)	CD	792 nm	822 nm
1,1'-dioctadecyl-3,3,3',3'-tetramethylindodicarbocyanine perchlorate (Dye 231)	DVD	645 nm	665 nm
1,1'-dioctadecyl-3,3,3',3'-tetramethylindo tricarbocyanine Iodide (Dye 232)	DVD	748 nm	780 nm
1,1',3,3,3',3'-hexamethyl indodicarbocyanine Iodide (Dye 233)	DVD	638 nm	658 nm
DTP (Dye 239)	CD	800 nm (33 ps)	848 nm
HITC Iodide (Dye 240)	CD	742 nm (1.2 ns)	774 nm
IR P302 (Dye 242)	CD	740 nm	781 nm
DTTC Iodide (Dye 245)	CD	755 nm	788 nm
DOTC Iodide (Dye 246)	DVD	690 nm	718 nm
IR-125 (Dye 247)	CD	790 nm	813 nm
IR-144 (Dye 248)	CD	750 nm	834 nm

Light-sensitive compounds may be chosen from any compound or combination of compounds that serve to change the output signal from the medium upon re-reading. These compounds include delayed emission compounds, delayed absorbance compounds and other light sensitive compounds. For example, a layer in the medium that becomes reflective upon re-reading may also be useful in predictably altering the output of the medium.

Light-sensitive compounds may be placed on the optical media in various thicknesses dependent upon the application. For example, if a phosphorescent compound is applied by a spin coating process, it may be dissolved in ethyl lactate and the compound may overcoat the entire disk. The thickness of the compound layer may be controlled by varying, among other factors, the rotational speed of the media during this process. In one embodiment, the compound layer may be from 120 nm to less than 1 nm thick. The desired thickness of the compound layer that is applied may be a function of the absorption of the compound, the emission of the compound, the density of the compound and the structure of the media, as well as the properties of the reader that is used to read the data off of the media. In one embodiment, the compound may be applied at a thickness that is thin enough to allow transmission of light to adequately read the underlying data upon initial sampling while being dense enough to provide adequate fluorescence upon re-reading with the same reader.

A film thickness of from 50 to 160 nm has been found useful. It is preferred that the film thickness for a CD is in the range from about 70 nm to about 130 nm. While film thickness for a DVD is preferably in the range of from 50 nm to 160 nm, of course other suitable thicknesses may be employed.

In another embodiment, a 5 nm thick layer of a light-sensitive compound was spin coated onto a CD. At a laser diode wavelength of 780 nm, the absorption by the compound was about 61% and the delayed fluorescence of the compound was about 12%.

In addition to coating a light-sensitive compound onto the media, the compound may be spotted at specific locations on the media. Light-sensitive compound may be placed at any depth within or on the media and is preferably at a position in the media where the reader can adequately focus on the compound.

Figure 4 illustrates an embodiment of the invention using an optical medium similar to that described in Figure 3. The digital output from the medium upon initial sampling is shown and is the same as the output from the medium illustrated in Figure 3. The optical disk 200

shown in cross-section in Figure 4 contains an additional light-sensitive compound layer 400 (not present in Figure 3) which is distributed through the disk in a position that is close to reflective layer 240. Although the security layer 400 is shown disposed within the substrate 210, the present invention is not limited in this respect and the light-sensitive compound may be dispersed in any other suitable location. Light-sensitive compound 400 may be cross-linked, for example, by laser catalysis, at specific locations to provide a delayed fluorescence compound at the specific locations. Referring to Figure 4, the location of activated compound is shown at locus 410. The data recorded on the disk, represented by a series of pits 220 and lands 230, is identical to that shown in Figure 3. In operation, a focused light source used to read the optical disk passes through light-sensitive compound layer 400 and a portion of the light is instantaneously reflected back through light-sensitive compound layer 400 so that the data output upon an initial reading is identical to that shown in Figure 3.

However, as is illustrated in Figure 5, activated compound locus 410 is excited by the light and due to the compound's delayed fluorescence, emits light at a certain wavelength several milliseconds later, for example. Through instructions provided on the disk, the reader has been directed to re-read the same locus 410 on the disk shortly after its initial sampling. In one embodiment, as illustrated in Figure 5, the reader re-reads locus 410 at about the time of the delayed fluorescence. The detector receives a different output than it does initially (as represented in Figure 4) due to the light provided by the delayed fluorescence of activated light-sensitive compound locus 410. Light-sensitive compound locus 410 has been placed and activated to mask pit 270. Referring back to Figure 3, showing a disk without light-sensitive compound 400, as the track passes through the focused light beam, transitions representing 1's are detected at points A, B, C and D as the transition is made from pit to land or land to pit. The same response is received from the medium in the embodiment shown in Figure 4, upon initial sampling. Referring now to Figure 5, representing the response received upon re-reading, the light-sensitive compound at locus 410 is masking pit 270 and as the track passes through the light beam, a transition is still recognized at point A, but the transitions at points B and C are not detected because the emission of light from light-sensitive compound locus 410 blocks the transition and instead is read as a continuation of the land between points A and B. The signal generated across this span during re-reading does not cross threshold level, and the next transition to be detected is at point D. Thus, from points A to D the raw 14 bit data signal is

read as 10010001001 prior to excitation of the light-sensitive compound at locus 410 (Figure 4) and is read as 10000000001 upon re-reading when the light-sensitive compound at locus 410 has been excited by a previous pass of the laser (Figure 5). The effective reflectance has been changed to simulate the removal of two transitions. In this manner, a different set of predictable data is read upon re-reading the same location that had been previously read by the same device. If the same location is re-read again after the compound emission has subsided, the initial reading of 10010001001 will be detected. The emission from the light-sensitive compound at locus 410 need not be as intense as that reflected back from a land but preferably is of adequate continuous intensity to prevent the signal from crossing the threshold.

Figure 6 illustrates an embodiment that uses a light absorbing compound to alter the data output from an optical medium. The data that has been recorded on disk 300 is identical to that shown in Figures 4 and 5. Inactive light absorbing compound has been disposed in a layer 500 across a portion of disk 300. Locus 510 has been activated to make the light absorbing compound active at point F. Upon initially reading the disk, the reader detects data that is equivalent to that detected in Figure 4, described above. Upon re-reading the data however, locus 510 has been excited by the previous pass of the laser, and, upon re-reading, absorbs light that is reflected off of land 530, and this light is therefore not detected. Whereas initially the data read from the track between points E and G was detected as 1000000001, upon re-reading the light absorbing compound has altered the data so that over the same section it reads 1001000001. Thus, the use of a light absorbing compound has added a transition where previously there was none.

By incorporating light-sensitive compounds having specific time delay in light emission and/or excitation and/or absorption at various wavelengths, with instructions to re-read specific areas on the media at time intervals based on the time delay, various copy prevention techniques may be formulated. Thus, any combination of sampling, re-reading and re-sampling of one or more locations on the media may be used. In addition, any combination of light sensitive compounds may be used to further vary the copy protection techniques.

Figure 7 is a schematic block diagram of a system 600 that may be used with various aspects of the invention. In this illustrative embodiment, the system 600 includes a data processing apparatus 610, which may be a general purpose computer, or network of general purpose computers, and other associated devices, including communications devices, modems,

and/or other circuitry or components necessary to perform the desired input/output or other functions. The data processing apparatus 610 can also be implemented, at least in part, as a single special purpose integrated circuit (e.g., ASIC) or an array of ASICs, each having a main or central processor section for overall, system-level control, and separate sections dedicated to performing various different specific computations, functions and other processes under the control of the central processor section. The data processing apparatus 610 can also be implemented using a plurality of separate dedicated programmable integrated or other electronic circuits or devices, e.g., hard wired electronic or logic circuits, such as discrete element circuits or programmable logic devices, and can also include any other components or devices, such as user input/output devices, a keyboard, a user pointing device, touch screen, etc.

The data processing apparatus 610 may communicate with a media reader 620, which may be a conventional CD, DVD or other optical media reader. Optical media, which may include one or more aspects of the invention may be read by the media reader 620, and information regarding the reading provided to the data processing apparatus 610. The data processing apparatus 610 may also communicate with a display 630 that provides a representation of the data read by and provided from the media reader 620. The display 630 may be a computer monitor, a CRT or LCD display, one or more audio speakers, a printer, or any other device or combination of suitable devices. As one example, the data processing apparatus 610, the media reader 620 and the display 630 may all be incorporated into a single DVD player, such that a user can have a DVD read and played back using the display 630.

The data processing apparatus 610 may also communicate with a data provider 650 or any other device through a communication system 640, such as the Internet, a wired or wireless telecommunications network, an infrared communication system, and the like. The data provider 650 may include a general purpose computer, or network of computers, or other devices capable of communicating with the data processing apparatus 610.

Figure 8 shows a schematic diagram of an optical medium 700 in an illustrative embodiment of the invention. In this embodiment, the medium 700 includes a light sensitive material 710 that is positioned on the medium 700 in three different locations or spots. Although in this embodiment the material 710 is positioned in three different locations, the light sensitive material 710 may be placed on or in the medium 700 in any number of ways. In one embodiment, the entire medium 700 or one surface of the medium 700 may be coated with light

sensitive material 710. In other embodiments, the material 710 is positioned at a number of discrete predetermined locations or in a random fashion. The light sensitive material 710 may be positioned so that it is located within precisely defined boundaries, or so that it is merely located roughly within a specified area. The shape and size of the areas of the medium 700 including light sensitive material 710 may not be important, as any underlying data may not be affected by the light sensitive material 710.

The light sensitive material 710 may be placed so that it lies in an optical read path of the media reader 620 so that the light sensitive material 710 is irradiated by light when the data is read. Alternately, the light sensitive material 710 may be placed in an area of the medium 700 that is not designed to hold recorded data or that includes dummy data that may not be required for use of other data on the medium 700. It should be understood, however, that the medium 700 need not include any data, but instead may be a "blank" medium 700 that can be written with desired data.

The light sensitive material 710 may be placed at any depth within the medium 700 between and including the surface of the medium 700 and an underlying data layer. For example, the light sensitive material 710 may be placed on the surface of the medium 700 through which light passes to read the underlying data. In another embodiment, the light sensitive material 710 is placed close to the recording layer of the medium 700 so that the focal distance to the light sensitive material 710 is similar to that of the recording layer. In another embodiment, the light sensitive material 710 is placed on the surface of the medium 700 and is then coated with a protective layer.

In addition to the size and shape of the placement, other factors may determine how a light sensitive material 710 may be illuminated to an extent great enough to change state. For example, the depth of the placement of the light sensitive material 710 within the medium 700 may be a factor in determining when a light source will be properly positioned to illuminate the material 710 to an extent necessary to provide a detectable response, i.e., change in state. For example, if polycarbonate is used as a substrate material of the medium 700, the polycarbonate substrate may act as a lens to focus a light beam so that the beam becomes more focused at locations closer to the underlying data track than near the surface of the polycarbonate opposite the data track. Therefore, an equally sized and shaped placement of light sensitive material 710 near the surface of the medium 700 may be illuminated during reading of a broader range of

underlying addressable data points than would be if the light sensitive material 710 were positioned in the substrate closer to the data track or the focal point of the light source. This may occur because the light beam is broader and less focused, covering more area, when it strikes the surface of the medium opposite the data layer, rather than when it is focused near the data layer. This may also result in a lower beam intensity at the surface of the medium than at the data layer and, accordingly, light sensitive material 710 placed close to the surface of the medium may be made denser or more sensitive in order to provide an adequate response.

The light sensitive material 710 may be positioned in or on the medium 700 by any number of methods including direct application, spin coating, molding the light sensitive material 710 into a substrate of the medium 700, and dispersing the light sensitive material 710 in a second material that is compatible with the medium 700 substrate. For example, the light sensitive material 710 may be dispersed in a prepolymer of polycarbonate, PVC or vinyl acetate and then fixed in a suitable pattern on the medium 700. The chosen light sensitive material 710 may exhibit long term stability under typical optical media storage conditions and may be light fast and non-reactive. In addition, materials 710 may be chosen based on compatibility with the polymer or other material that is used to produce a substrate for the medium 700. The light sensitive material 710 may be included with the medium 700 before, during or after data has been written or otherwise provided on the medium 700.

The light sensitive material 710 may be any material that is affected by light, for example, by becoming reflecting, absorbing or emitting when illuminated by a light source. The light source may be a data reading light, such as a media reader 620 laser or other light source. The light sensitive material 710 may change between two or more states. For example, the material 710 may be alterable between emissive and non-emissive states, absorbent and non-absorbent states, or reflective and non-reflective states. The material 710 may alter states when excited by a light source, such as a laser, and later change states again with or without any further illumination. Thus, the light sensitive material 710 may change from a first state to a second state after illumination, and later change from the second state to the first state without being illuminated again.

The light sensitive material 710 may also have a delay in its change from one state to another after being illuminated. For example, the material 710 may be non-emissive for a delay period after excitation by a light source and then may become light emissive after the delay. For

example, the material 710 may be light absorbent upon illumination, and after a delay period become light emissive. In another embodiment, the light sensitive material 710 may emit light at one wavelength in a first state and then, after additional excitation, emit light of a different wavelength in a second state.

The light sensitive material 710 may have persistence, e.g., a time period during which the light sensitive material 710 remains in an altered state (e.g., light emitting) before changing to another state (e.g., transparent) absent sufficient illumination or other excitation while in the altered state. The persistence may vary widely, e.g., from 1 nanosecond to 1 minute or more. For example, a light sensitive material 710 may switch from a first state to a second state after being illuminated by an appropriate light, and remain in the second state for its persistence time, e.g., 1.6 ms, before changing back to the first state (absent sufficient illumination or other excitation while in the second state).

In another aspect, the dyes are chosen so that they emit at wavelengths that are the same or close to the same as the wavelengths that are detected by the readers. For example, for use with a CD, the security dye may emit at about 780 nm and for use with a DVD, the security dye may emit at a wavelength of about 650 nm. The chosen security dyes may exhibit long term stability under typical optical media storage conditions and the dyes may be light fast and non-reactive. In addition, dyes may be chosen based on the dye's compatibility with the polymer or other material that is used to produce the optical media.

Security dyes may be chosen from any compound or combination of compounds that serve to change the output signal from the medium upon resampling. These compounds include delayed emission, delayed absorbents and other light sensitive compounds. For example, a layer in the medium that becomes reflective upon oversampling may also be useful in predictably altering the output of the medium.

These dyes can be chosen from any inorganic compounds capable of emitting phosphorescent such as Zinc Sulfide(ZnS) at various concentration (Seto D, Rohrabacher C, Seto J Hood L. *Anal Biochem (1990)*, 189, 51-3.) ZnS-SiO_2 , Zn_2SiO_4, La_2O_2S, or any other rare earth sulfide, rare earth oxysulfide, rare earth oxide by itself or in combination with any metal ions such as Manganese (Mn), Copper (Cu), Europium (Eu), Ruthenium (Ru), EuF_3, Samarium (Sm), SmF_3, Terbium (Tb), TbF_3, Thulium (Tm) , Aluminum (Al), Silver (Ag), Magnesium (Mg), these compounds can be used as such pigments (very fine particle size), as

dispersions or when packed in a crystal lattice. (Draper DE. *Biophys Chem. (1985)*, 21, 91-101.) Phosphorescent and luminescent properties of these compounds can be altered in a ZnS crystal lattice depending upon the ions used for binding and delay time and the wavelength at which they emit can be controlled by changing the metal ions used for binding. (see, e.g., US Patent 5,194,290).

In a preferred embodiment security dyes organic/inorganic dyes can be placed in phase change layer in case of rewriteable CD and DVD phase change layer is made up of an alloy with compounds Germanium(Ge), Antimony(Sb) and Tellurium(Te) (e.g. $Ge_1Sb_2Te_4$ $Ge_2Sb_2Te_5$) or an alloy with compounds Sb(Antimony), Cd (Cadmium) and Sn(Tin).

Security dyes may be placed on the optical media in various thickness dependent upon the application. For example, if a phosphorescent dye is applied by a spin coating process, it may be dissolved in ethyl lactate and the dye may overcoat the entire disc. The thickness of the dye layer may be controlled by varying, among other factors, the rotational speed of the media during this process. In one embodiment, the dye layer may be from 120 nm to less than 1 nm thick. The desired thickness of the dye layer that is applied may be a function of the absorption of the dye, the emission of the dye, the density of the dye and the structure of the media, as well as the properties of the reader that is used to read the data off of the media. In one embodiment, the dye may be applied at a thickness that is thin enough to allow transmission of light to adequately read the underlying data upon initial sampling while being dense enough to provide adequate fluorescence upon oversampling with the same reader.

A film thickness of from 50 to 160 nm has been found useful. It is preferred that the film thickness for a CD is in the range from about 70 nm to about 130 nm. While film thickness for a DVD is preferably in the range of from 50 nm to 160 nm.

In another embodiment, a 5 nm thick layer of a security dye was spin coated onto a CD. At a laser diode wavelength of 780 nm, the absorption by the dye was about 61% and the delayed fluorescence of the dye was about 12%.

Security dyes may be chosen from those that exhibit a stability that provides a useful dye for the expected lifetime of the optical media.

In another embodiment for a precise placement of security dyes, at pit level, security dyes can be formulated with a UV cure resin or any other photoinitiator which are able to effect cures in the wavelengths (400-800 nm) as well as in the UVA, UVB and UVC range (254-365) and then

laser beam of appropriate wavelength can be used for curing the resin for precise placement of the dye embedded in the resin.

In another embodiment Fluospheres® (fluorescent microspheres) available from Molecular probes Oregon, USA can be used for a precise placement of security dyes at pit level as these Fluospheres® beads can be made from .02μm –4.0 μm size.

In another embodiment Quantum dots or nanocrystals can be used as security dyes. (Peng X.G, Schlamp M.C, Kadavanich A.V & Alivisatos A.P, *J. Am. Chem.Soc.* (*1997*), 119, 7019-7029.)

As would be understood by one of ordinary skill in the art, the persistence of the activated state of the light-sensitive material, (*i.e.*, the length of time the material is in the activated state versus initial state) and the delay in the conversion of the initial state to the activated state (*i.e.*, the length of time it takes the material to enter the activated state from the initial state) are helpful to permit the proper read of the underlying data, and for causing a change in the data read upon re-sampling. Given a pit size of 8 μm, a diameter of 120 mm, and a typical rotational speed of 1.2 m/sec in a CD-ROM, the preferred delay in a CD is a minimum of about 6.85×10^{-7} seconds. Given a pit size of 0.4 μm, a diameter of 120 mm, and a rotational speed of about 3.5 m/sec in a DVD, the preferred delay in a DVD is a minimum of about 1.14×10^{-7}. If the delay is too quick the data below the light-sensitive material will be obscured prior to read.

The rotation speed, that is the time it takes for a reader to get back to the same area on the disk, differs for conventional CDs and DVDs. The persistence of the activated state should at least last this long. Given a 120 mm diameter and a rotational speed of about 1.2 m/sec, the light-sensitive material placed on a CD should display a persistence of at least about 300 msec. Given a 120 mm diameter, and a rotational speed of about 3.5 m/sec, the light-sensitive material placed on a conventional DVD should display a persistence of at least about 100 msec. If the persistence is too short, the activated state will not be seen to obscure the underlying data upon re-sampling. Of course, if persistence is too long it may not allow the data on the disc to be read in an acceptable time after activation of the light-sensitive material. Persistence of certain inorganic light-sensitive materials, such as zinc sulfate, can be controlled by altering the particle size. When certain inorganic compounds are placed in a lattice the persistence of the activated state may also be changed. For example, the persistence of fluorescence of ZnS can be altered

by placing the compound in a lattice of silicon oxide and by including rare earth metal, copper and Mn as coordinate compounds in different combinations.

It is generally preferred that the particle size be less than 100 nm, more preferably less than 10 nm, and no more than the pit size of the optical disc being read (about 0.8 μm for the conventional CD, and about 0.4 μm for the conventional DVD). The light-sensitive material should be placed on the disc in a manner that the coating is not so thick as to cause scatter and incoherence. Preferably, any coating of the light-sensitive material should be less than 100 nm. When the light-sensitive material changes reflectivity upon activation, the minimum change in the index of refraction on a pit/land based optical disc should be at least about 0.3 to 0.4 to correspond to the change in index of refraction between a pit and a land.

The medium 700 may include data for digital files, such as data sets, computer programs, sound, images and video. The light sensitive materials 710 may be applied to the medium so that the presence of the materials 710 may or may not be detected during an initial reading or in a single read operation using conventional oversampling. If the materials 710 are chosen so that their presence cannot be detected during a single read using oversampling, e.g., the delay time is greater than the total read time including oversampling, the reader 620 may be directed to reread the same area of the medium 700 a short time after an initial read, and the light sensitive material 710 may have changed states.

Although light of a different wavelength and intensity than that used in conventional optical media readers 620 may be employed to illuminate the light sensitive material 710, it may be advantageous to used light sensitive compounds that respond to light sources that are used in conventional readers. In addition, it may be preferable that the light sensitive compounds are detectable by conventional readers 620. However, the light sensitive material 710 may be replaced with other materials that change state when exposed to a signal other than light, such as an electric or magnetic field, a rise in local temperature, etc. One example may be a material that changes state in response to a rise in local temperature, e.g., caused by the reading light of an media reader 620 or other heat source, such that the state change can be detected by the reader 620 light.

Having described some of the ways in which a light sensitive material 710 may be provided in association with an optical medium 700, examples regarding how the light sensitive material 710 may be used in a few illustrative embodiments are described. It should be

understood that various aspects of the invention described above and/or in the following Examples may be used singly or combined together in various ways in a single device or application.

Example 1

In one illustrative embodiment, the presence of light sensitive materials 710 on a medium 700 is used to determine that the medium 700 is an authorized medium 700 and/or contains data authorized for a particular use. In this embodiment, the light sensitive material 710 on the medium 700 is used by an installation program to prevent unauthorized installation of software recorded on the medium 700 on a computer, but the same or similar technique may be used to prevent unauthorized use of the medium 700, unauthorized use, such as reading or writing, of data on the medium 700, and so on. In this example, the installation program along with data representing the software code are recorded on the medium 700, but the installation program may be provided in other ways, such as stored in a memory of a media reader 620, on another medium 700, etc.

When an attempt is made to install the software on the medium 700 shown in Figure 8, the installation program is read from the medium 700, e.g., by the media reader 620, and implemented by the data processing apparatus 610. The installation program includes instructions to verify that the software to be installed is contained within an authorized medium 700. Part of the authentication procedure may involve reading portions of the medium 700 in a defined sequence and/or at a defined timing. The read sequence and timing may be stored as part of the installation program or may be determined randomly, e.g., by the program using a random number generator. For example, the installation program may direct the media reader 620 to read portions of the medium 700 within sectors 700a-700f in order during a first read. Depending upon the nature of the light sensitive material 710, the reader 620 may not detect the presence of the light sensitive material 710 during the first read, and output a signal representing the read result. The reader 620 may not detect the light sensitive material 710 if, for example, the delay time of the material 710 is longer than the read time for each sector 700a-700f. As discussed above, the light sensitive material 710 may be positioned on the medium 700 in association with actual target or useable data, such as portions of the software program, or in association with dummy data. Thus, the reader 620 may output a signal representing dummy data read from each of the sectors 700a-700f after the first read. For simplicity and as one

example, the reader 620 may output a signal "000000", where each "0" represents the dummy data read from each of the six sectors 700a-700f during the first read.

Next, the installation program may instruct the media reader 620 to again read the sectors 700a-700f in that order during a second read. Each sector 700a-700f is to be read at a timing such that the second read of the sector 700a-700f occurs after a delay time (if any) and within a persistence time for the light sensitive material 710. That way, assuming the first read of each portion of sector 700a, 700c and 700e was sufficient to illuminate the light sensitive material 710 and cause the material to change state, the second read will be performed while the light sensitive material 710 is in its changed state. Since the light sensitive material 710 is in its changed state during the second read cycle, the media reader 620 will output a signal representing a read where the light sensitive material 710 in its changed state was encountered. For example, the media reader 620 may output a signal "101010" for the second read, where the "1"s represent a read where light sensitive material 710 in a changed state was encountered in sectors 700a, 700c and 700e and the "0"s represent a read dummy data read in sectors 700b, 700d and 700f. Reading of sectors 700a, 700c and 700e during the second cycle may result in the media reader 620 reading different data than that during the first read, e.g., the dummy data under the light sensitive material 710 may include a string of "0"s while the light sensitive material 710 during the second read cycle may cause the reader 620 to read a string of "1"s. The light sensitive material 710 may have other affects on the reading of the medium 700 during the second read cycle, such as causing the reader 620 to output an "end of file" signal, a signal indicating that the medium 700 is not readable, or some other indication of the light sensitive material 710 being in an altered state.

By comparing the two signals generated during the first and second read cycles, e.g., determining that the two reads provided different results from reading the same portions of sectors 700a-700f, the installation program may determine that the medium 700 is an authentic medium (as opposed to an unauthorized copy) and allow installation of the software program to continue. Otherwise, the installation program may deny installation of the program.

The installation program need not necessarily require a precise match between an expected output from a media reader 620 during an authentication process and the actual output. Instead, the installation program may only require that the actual output from the media reader 620 be within a desired range of values. Using a simplified extension of the example above,

light sensitive material 710 may be provided in any one of the sectors 700a-700f during manufacture, as long as at least one sector includes light sensitive material 710. In this case and using the example provided above, the installation program may accept actual output from the media reader 620 during the second read cycle between the range "000001" and "111111" are acceptable for authentication purposes.

Since a relatively large area of each sector 700a-700f may be read during authentication, precise positioning of the light sensitive material 710 within each sector may not be required. Instead, approximate positioning may be adequate. In addition, the medium 700 may be conceptually divided into more than, or fewer than, six sectors 700a-700f, if desired. An increase in the number of sectors may provide a larger number of possible locations for light sensitive material 710, and therefore provide a more complicated and robust protection scheme. Further, each medium 700 may have a unique distribution of light sensitive material 710 in its sectors as compared to other media 700 in a group. Thus, a unique code may be provided on each medium 700 using the light sensitive material 710 positioned in different locations. Protection may be further enhanced by varying the delay times and/or persistence of light sensitive materials 710 positioned on the medium 700.

Example 2

Those of skill in the art will appreciate that Example 1 described above may be altered in many ways to provide different and/or varying levels of protection. As a second example, authentic media 700 may be provided with an alphanumeric security code that is unique to each disk and is printed on a card accompanying the media 700. At the time of installation, the installation program may request the user to enter the security code. The installation program may then use the code to verify the authenticity of the medium 700 having the software to be installed. For example, the installation program may use the security code to determine a sector 700a-700f read sequence and/or timing, as an encryption key or password, to determine where on the medium 700 light sensitive material 710 is positioned, to determine an expected output from the media reader 620 when using a predefined sector read sequence, and so on. Based on this information, the medium 700 may be read, and the output from the reader 620 compared to expected output determined based on the security code.

The security code may alternately be included on the medium 700 based on the way the light sensitive material 710 is positioned on the medium 700, e.g., in a way similar to a conventional barcode, and/or other features of light sensitive material 710, such as a delay time and/or a persistence for each spot of light sensitive material 710. As one example, the installation program could instruct the media reader 620 to initially read the medium 700 in a way that the presence and location of light sensitive material 710 on the medium 700 is determined. If other features of delay and/or persistence of the light sensitive material 710 are used to encode the security code, the installation program could then read the light sensitive material 710 locations in various ways to determine the delay and/or persistence of the material 710 and use that additional information to determine a security code and/or authenticate the medium 700. For example, the installation program could instruct the media reader 620 to read each location of light sensitive material 710 using different read delay times of 1ms, 10ms and 100ms. If a change in state of the light sensitive material 710 is detected after a delay time of 10ms, but not after 1ms and 100ms, a determination may be made that the delay time of the light sensitive material 710 is between 1ms and 10ms, and the persistence is less than 99ms. This information, along with position information regarding the material 710 location, may be used to determine/decode a security code, a medium identification number, an alphanumerical sequence or other information provided by the pattern of light sensitive material 710 on the medium 700. Decoded information may be used to determine characteristics of the medium 700 and compare those characteristics to characteristics sensed during the authentication process. For example, a decoded medium identification number may be used to determine, e.g., using stored information, that the medium 700 should include light sensitive material 710 in specific locations, and having specific delay times and/or persistence. This information may be compared to the sensed location, delay time and persistence values determined during reading of the medium 700. The comparison may result in determining that the medium 700 is authentic and authorized for use (reading, writing, alteration of data on the medium 700 and so on), or that use of the medium 700 should be denied.

Example 3

In the examples described above, no distinction was made regarding reading specific portions of a medium 700 that is associated with a single spot of light sensitive material 710. In

this illustrative embodiment of the invention, different portions of a medium 700 that are associated with a single spot of light sensitive material 710 are read. Figure 9 shows a portion of the medium 700 and a spot or area of light sensitive material 710. Although the medium 700 may have a plurality of regions each associated with a corresponding spot of light sensitive material 710, only the reading of a single portion of the medium 700 is discussed below for simplicity. In addition, the light sensitive material 710 is associated with four tracks a-d in Figure 9, but light sensitive material 710 may be placed in or on a medium 700 so that it is associated with any number of adjacent tracks.

Part of an authentication procedure for the medium 700 may involve reading a plurality of tracks a-d on the medium 700 that are all associated with a spot of light sensitive material 710. The location of spots of light sensitive material 710 may be determined as described above, e.g., by searching the medium 700 for regions, by referring to a look up table that corresponds a medium identification number with specific, expected material 710 locations, and so on. Reading of the tracks a-d may be performed for the same or similar purpose as reading portions of the medium 700, such as determining a security code for the medium 700, verifying the presence of light sensitive material 710 on the medium 700 (e.g., in specific locations, and/or having specific properties such as delay time and persistence), and so on. However, in this embodiment, if any point along tracks a, b, c or d that are associated with the light sensitive material 710 are read by a light source, the light sensitive material 710 may be caused to alter state. That is, illumination of any of the tracks a-d for reading may illuminate the light sensitive material 710 and cause it to change from one state to another. For example, if the reader 620 is directed to sample a section of track a, and light sensitive material 710 is a fluorescent compound having a delay time of 10ms, then reading of track a, b, c or d 10 ms after illumination during the first read may result in the reader 620 detecting the presence of the light sensitive material 710, since illumination of a portion of the light sensitive material 710 may cause the entire spot of the material 710 to change state.

However, if the response of the light sensitive material 710 is different, e.g., only illuminated portions of the light sensitive material 710 change state, the reading of track a may cause only a portion of the light sensitive material 710 associated with an adjacent track(s) to change state (in addition to the portion associated with track a). This may be caused as a result of the light beam reading track a covering an area larger than that defined by the target track a,

e.g., the light sensitive material is in a different focal plane that the track. Thus, the light beam may illuminate portions of the light sensitive material 710 that is associated with track b, but not portions associated with track c or d. In addition, the light sensitive material 710 may be excited by light beams used to aid in tracking as well as the light beam used for reading data. These additional light beams may further broaden the area of light sensitive material 710 that may be excited by a single read. As a result, reading of track a, followed by reading of track b after the delay time (if any) and within the persistence time of the light sensitive material 710 may result in the media reader 620 detecting that the light sensitive material 710 is in a changed state when reading track b.

As one example, the media reader 620 may be directed to read track a, track b, track d, then track c. Given that the readings occur within an amount of time greater than the delay of the light sensitive material 710 and during the persistence time, the reader 620 will read data unaffected by the material 710 from track a, detect that the light sensitive material 710 is in an altered state while reading track b, read data unaffected by the material 710 from track d, and detect that the material 710 is in an altered state while reading track c. Of course, reading of tracks a-d may be performed in any suitable order, and with any delay. The result of the reading may be used as discussed above, to authenticate the medium 700, to determine a security code, identification number or other information for the medium 700, and so on. In addition, the light sensitive material 710 need not be precisely positioned with respect to the tracks a-d. In fact, imprecise or random placement of the material 710 may be used to create unique patterns of material 710 on each medium 700. By including material 710 at multiple spots with light sensitive material 710, a sophisticated read sequence may be required to accurately obtain the underlying data. If the proper read sequence is followed, the data may be used for its intended purpose. However, if an improper read sequence is used, for example, if the reader simply proceeds along the tracks in a sequential fashion, the material 710 will interfere with the reading of the underlying data resulting in an inoperable data set.

As with the other examples described above, the areas of light sensitive material 710 may be made large enough to avoid error correction techniques, such as EFM, from masking detection of the material 710 in an altered state. For example, to prevent masking of error correction techniques, the material 710 may be placed over (or under or both over and under) 50,000 or 100,000 adjacent bits of data, or over (or under or both over and under) approximately

2mm on a conventional CD. Therefore, only when the required read sequence, including appropriate jumps and delays, is implemented will the underlying data be properly read from the medium 700.

This same feature that one or more tracks may be made unreadable by previous reading of an adjacent track can be used to prevent serial copying of data on a medium 700 or copying of data on the medium 700 while not using an appropriate reading sequence (which may involve reading different regions at different times to account for the location, delay and/or persistence of light sensitive material 710 on or in the medium 700). For example, an entire medium 700 may be coated with a light sensitive material 710 so that data stored on the medium 700 cannot be sequentially read from medium 700 unless a first portion is read, thereby causing the light sensitive material 710 to alter state, and a next adjacent portion associated with the material 710 that has changed state is read after the material 710 has reverted back to its unaltered state. Reading of the medium 700 sequentially without appropriate timing may result in unusable data being read from the medium 700 caused by the media reader 620 reading light sensitive material 710 that is in an altered state.

Similarly, light sensitive material 710 and data may be positioned in strategic locations on the medium 700 so that the data may only be successfully read when the data is accessed using a particular access sequence. The access sequence may be stored as part of the data on the medium 700 (and possibly encrypted), provided by a user as an alphanumeric code, and/or stored/encoded by the location, delay and/or persistence of the light sensitive material 710 on the medium 700, similar to that described above.

As with the other examples, various combinations of materials 710 exhibiting absorbence, emission, and reflectance, for example, may be used. In addition, compounds exhibiting various delay times and persistence times may be used together to create a more sophisticated protection system. If the disk is copied, for example, by bit-to-bit copying, the light sensitive materials 710 may not be copied, and thus the copied version of the data will be uninstallable, unreadable or otherwise unusable. This will hold true whether or not the user of the unauthorized copy has access to the user code or owns an authorized copy.

Example 4

Using another aspect of the invention, optical media 700, such as CDs and DVDs, may be read only for a limited amount of time or a limited number of readings. For example, the medium 700 may include light sensitive material 710 that will fade or otherwise be undetectable after a certain amount of time, e.g., one month, or after a certain number of readings, e.g., after three readings. The light sensitive material 710 may be used in any of the ways described above, e.g., applied in spots on the medium 700 and used to authenticate the medium 700. After the material 710 fades or is otherwise undetectable, data on the medium 700 will no longer be accessible. Alternately, the material 710 may be used to encode actual useable data on the medium 700, e.g., data portions of a DVD movie, and after the material 710 is no longer detectable, the medium 700 will effectively be blank or partially so. This type of temporary medium 700 may be useful in the movie or software rental industry, because the medium 700 will no longer be useable to the renter after authorized use of the medium 700 and/or its content is complete.

For example, the light sensitive material 710 may be a persistent light sensitive compound placed at a specific location on the medium 700. The persistence of the material 710 may be known to decrease with age, or use, such that after three plays the persistence decreases from 2 ms to less than 1ms, for example, at a detectable intensity. Therefore, prior to allowing the medium 700 to be accessed, the location at which the light sensitive compound 710 has been placed is read and then re-read after about 1 ms. If a response is detected from the light sensitive material 710 upon re-reading, the persistence is still greater than 1 ms, and reading of the data may proceed. If no response from the light sensitive material 710 is detected, the persistence time has dropped below the acceptable level and access to the data is denied. In this manner, by varying the amount of time from initial read to re-read, the same medium 700, with the same light sensitive material 710 in the same location, may be provided with different useful lifetimes. For instance, data access may be provided or denied based on threshold re-reading times of 1.5, 1.0 or 0.5 ms, with 1.5 ms corresponding to a medium 700 that is one month old, 1.0 ms corresponding to a medium 700 that is 3 months old, and 0.5 ms corresponding to a medium 700 that is a year old.

In addition to providing only a limited number of uses, the medium 700 may also incorporate copy and/or access protection techniques, such as those used in the examples above.

For instance, phosphorescent compounds may be placed at various points on the medium 700 and persistent readings must be detected from these locations prior to proceeding with playing the disk. In this manner, a copy protected temporary data file capable of only a limited number of uses is provided.

Example 5

In another embodiment of the invention, an optical medium 700, such as a CD or DVD, may contain a version, or portion, of a movie, audio file, program or data file that may be freely used and duplicated. For example, this may be a demo version of a piece of software or the trailer of a movie. The optical medium 700 may also contain an access protected file which may include, for example, the entire software program or the full length DVD movie. In order to access the full version of the program, movie or audio file, the user must input a code which can be obtained from an authorized source and may be specific for a particular optical medium 700. Once the code has been input, the proper installation sequence or reading sequence may be implemented, e.g., the expected position and type of light sensitive material 710 on the medium 700 verified, and the full version of the data can be accessed. In addition to limiting access, the invention may be used to prevent copying in a manner similar to those outlined above. Thus, even after an owner is provided with an access code, additional functional copies may not be made.

Example 6

Another aspect of the invention may allow data files, such as movies, software and music, to be safely transmitted over the Internet and recorded onto an optical medium 700 where an authorized user may have full access to the content.

For example, a "blank" optical medium 700 may be provided (either "free" or purchased) with a data recording layer and light sensitive materials 710 associated with various portions of the medium 700. The pattern of light sensitive material 710, for instance, a phosphorescent compound, may be unique to this particular medium 700 or to a small group of media 700. A user of the medium 700 can contact a data provider 650 of content using a data processing apparatus 610 over a communication system 640, such as the Internet, and request a particular data set, such as a DVD movie or software. When the user decides to purchase or rent

the content, for example, a movie, a unique code for the medium 700 may be detected by the media reader 620 that is specific to the pattern of light sensitive material 710 on the medium 700. The media reader 620 may determine the code by reading the medium 700 using read instructions received from the provider 650, using instructions stored on the medium 700, using a set of standard read instructions, and so on. This unique code may then be transmitted to the data provider 650. Alternately, the user could provide a code, such as a serial number or other identifier, for the medium 700 by typing the code into the data processing apparatus 610 and sending the code over the communication system 640.

Based on the code, the data provider 650 may create a protected version of the requested data. The protected or encrypted version of the movie may be inoperable in the form in which it is transmitted from the provider 650 to the user. Thus, if the file sent by the provider 650 is intercepted during transmission, the file will not be useable unless associated with the appropriate medium 700. Because the code that was transmitted to the provider 650 provides information about the pattern of light sensitive material 710 on the medium 700, the encrypted file that is transmitted may be uniquely produced to work only on the specific medium 700. Thus, only when the data is recorded onto the unique medium 700 may the file become usable. Once the data has been written to the medium 700, it may be used an unlimited number of times if a permanent data recording technique has been used, or alternatively, a temporary recording surface or light sensitive material 710, such as that described in Example 4 above, may be used to produce a medium 700 capable of a limited number of plays.

Because the medium 700 may require the presence of light sensitive material 710 in particular locations, having a particular delay and/or persistence to be accessible, byte-to-byte copying of the medium 700 may result in an inoperable data file. In this manner, a producer or distributor of copyrighted material may either charge for the blank medium 700 or charge for the download and can be confident that only a single copy of a content will be made and used. In an alternative embodiment, a medium 700 having a unique code of light sensitive material 710 may be used as a key to unlock an encrypted file on another medium 700 and the unlocked complete file may be copied onto a second disk that includes copy protection features, such as those described above. In this way, a single unique disk can be used to download multiple movies, songs or programs allowing for efficient accounting and billing methods.

The light sensitive material 710 may be used in different ways to allow access to the data stored on the medium 700. For example, the data transmitted by the provider 650 may have 1000's of inborn errors that are corrected by the light sensitive material 710, e.g., when the data is written to the medium. That is, the data may be constructed so that the error portions of the data are written on the medium 700 in portions that are associated with spots of the light sensitive material 710. Thus, using an appropriate read sequence and/or timing, the material 710 may be altered in state so that the incorrect data is masked or corrected by the material 710 during reading. For example, the material 710 may have a delay time that is less than half the total time required to read data from the medium using oversampling. This results in the read of the material 710 providing corrected data while masking the incorrect data. Of course, the delay time may be longer than a single read time using oversampling. In this case, the material 710 may have to be altered in state before being read to provide corrected data. In this embodiment, the material 710 may be configured or chosen so that the data may be written on the medium 700 without altering the state of the material 710, e.g., the delay time of the material 710 is less than the write time. This way, the data may be written to the medium 700 without interference from the material 710.

Alternately, the material 710 may provide information regarding which data portions contain errors and how to correct the errors. For example, before or during reading of the data, the data processing apparatus 1 and/or the media reader 620 may identify which areas of the medium 700 contain light sensitive material 710 (based on a detected change in state) and cut out data portions located in those areas or otherwise process the incorrect data. By using thousands of spots of material 710 arranged in a unique pattern on each medium 700, manual or automatic correction of the data in an attempt to make an unauthorized copy may be made very difficult or impossible.

Another possibility is to store encrypted data on the medium 700 and use a decryption key that is determined based on characteristics of the light sensitive material 710 on the medium 700 to decrypt the data. For example, a pattern of light sensitive material 710 on the medium 700 may provide an encryption key when read in a particular way, e.g., in a specific sequence, at a specific timing and so on. This key can be used to decrypt the data, e.g., in real time during play back, or authorize use of the data on the medium 700.

The material 710 may also provide a watermarking function such that reading of the data on the medium 700 using an improper accessing sequence, e.g., a sequential copy sequence, may result in including data read from material 710 in an altered state being included in the copy. This data, which is different from data included in an authorized copy, may provide a kind of watermark that can be used to identify that the copy is an unauthorized one, and/or the source of the copied data.

A variety of techniques are available for implementing different aspects of the invention. For instance, as described above, the output of underlying data may be altered by the presence of a light sensitive material.

Light sensitive materials 710 have been chosen and described for use in the examples above, in part, because of the current popularity of optical storage media and because they may provide a convenient way of protecting stored data without requiring alteration of conventional optical media readers. It should be understood, however, that various aspects of the invention may be extended to use of other types of materials, such as materials that change state or otherwise respond to signals other than light, or other types of storage media. For example, materials that change state in response to an electric or magnetic field may be used in place of the light sensitive materials 710. The materials may be used in media that are optically read, or in media that are read using other signals. As one example, a material that changes state in response to an electric field and effects light in different ways based on its state, such as a liquid crystal material that changes state in response to an electric field and alters the polarization of light passing through the material, may be used in place of, or in addition to, the light sensitive materials 710. In such cases, media readers may have to be altered to accommodate the different type of material, e.g., by including a device to create an electric field at desired locations on the medium 700. Thus, the invention is not limited to the use of light sensitive materials, or to application to optical storage media only.

In addition, in the examples described above, the light sensitive materials 710 affect reading of a medium 700 after being exposed to light and changed to an altered state. However, the materials 710 may operate to affect reading of the medium 700 in a first state and not affect reading in a second state. For example, a material 710 may be light absorbing prior to being illuminated by an optical reading light. After a possible delay time, the material 710 may change state to be transparent such that the material 710 allows reading of data under the

material 710. After some persistence time, the material 710 may return to the first absorbing state, thereby preventing reading of data under the material. Further, the light sensitive material 710 may affect reading of data on the medium in two or more of its states. For example, the material 710 may always prevent reading of data under the material 710 as long as the material 710 is detectable. In a first state, the material 710 may cause a reader to read a first data type, such as a "0", and in a second altered state may cause the reader to read a second data type, such as a "1". The material 710 may be temporary such that after an amount of time or a number of readings the material 710 is no longer detectable, thereby allowing data below the material 710 to be read.

Having thus described certain embodiments in the present invention, various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be within the spirit and scope of the invention. Accordingly, the foregoing description is by way of example only, and is not intended to be limiting. The invention is limited only as defined in the following claims and the equivalents thereof.

CLAIMS

1. A method for authenticating an optical storage medium having an optical data structure representative of a series of bits, the method comprising:

(a) reading the optical storage medium at a locus to obtain data true to the series of bits represented by the optical data structure at such locus;

(b) re-reading the optical storage medium at the locus to determine if the data obtained varies by one or more bits in the series of bits represented by the optical data structure at such locus; and

(c) authenticating the optical storage medium if the data obtained in step (b) differs from the data obtained in step (a).

2. The method of claim 1 further comprising re-reading the optical storage media at a second locus.

3. The method of claim 1 wherein the data obtained in step (a) produces a signal that is inadequate to provide for an intended use of data stored on the medium.

4. The method of claim 3 wherein the data obtained in step (b) produces a signal that is adequate to provide for an intended use of data stored on the medium.

5. The method of claim 1 wherein the data obtained in step (a) comprises at least a portion of a file allocation statement.

6. The method of claim 1 wherein re-reading at the locus occurs within about one second of reading at the locus.

7. The method of claim 6 wherein re-reading at the locus occurs within about ten milliseconds of reading at the locus.

8. The method of claim 7 wherein re-reading at the locus occurs within about one millisecond of reading at the locus.

9. The method of claim 1 further comprising providing the optical storage medium with a light-sensitive compound.

10. The method of claim 9 wherein re-reading at the locus comprises reading a signal from the light-sensitive compound.

11. The method of claim 9 further comprising providing a light-sensitive compound in the optical path of the locus and an optical detector.

12. The method of claim 9 wherein the light-sensitive compound has an emission wavelength at a wavelength detectable by a detector in an optical reader.

13. The method of claim 9 wherein the light-sensitive compound absorbs light that, in the absence of the light-sensitive compound, would be detected by a detector in an optical reader.

14. The method of claim 12 wherein a light emission from the compound provides at least a portion of the data obtained in step (b).

15. The method of claim 12 wherein the light-sensitive compound is excitable by light emitted by a light source in the optical reader.

16. The method of claim 9 wherein the light-sensitive compound has an emission wavelength from about 770 nm to about 830 nm.

17. The method of claim 16 wherein the light-sensitive compound has an emission wavelength of about 780 nm.

18. The method of claim 9 wherein the light-sensitive compound has an emission wavelength from about 630 nm to about 650 nm.

19. The method of claim 9 wherein the light-sensitive compound has an emission wavelength of about 530 nm.

20. The method of claim 9 wherein the light-sensitive compound has an emission wavelength in the near infrared range.

21. The method of claim 9 wherein the compound is luminescent.

22. The method of claim 9 wherein the compound is phosphorescent.

23. The method of claim 9 wherein the compound has an emission wavelength of about 780 nm, or about 530 nm, or both.

24. The method of claim 1 wherein the optical recording medium is selected from the group consisting of CD, CD-Audio, CD-ROM, CD-G, CD-i, CD-MO, CD-R, CD-RW, DVD, DVD-5, DVD-9, DVD-10, DVD-18, DVD-ROM and any optical recording medium.

25. The method of claim 9 wherein the compound is a cyanine compound.

26. The method of claim 9 wherein the compound is selected from the group consisting of indodicarbocyanines, benzindodicarbocyanines and hybrids thereof.

27. A data storage medium readable with a reader, the data storage medium comprising:

a substrate;

optical data structure on the substrate, the optical data structure representative of a plurality of data bits; and

a material capable of existing in at least a first optical state and a second optical state, the first optical state being convertible to the second optical state upon exposure to an input signal, and the second optical state being spontaneously convertible after a period of time to the first optical state;

wherein the material is positioned at one or more discrete loci along the data storage medium in respect of the optical structure, such that when the data storage medium is first read at a locus, and the material is in its first optical state, the bit data read is true to the optical data structure at such locus, while when the data storage medium is re-read at the locus, and the material is in its second optical state, the data bit read varies by one or more bits from that true to the optical data structure at the locus.

28. The data storage medium of claim 27 wherein the data obtained when the data storage medium is first read produces a signal that is inadequate to provide for an intended use of data stored on the medium.

29. The data storage medium of claim 28 wherein the data obtained when the data storage medium is re-read produces a signal that is adequate to provide for an intended use of data stored on the medium.

30. The data storage medium of claim 27 wherein the data obtained when the data storage medium is first read comprises at least a portion of a file allocation statement.

31. The data storage medium of claim 27 wherein the material is a light-sensitive compound.

32. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength at a wavelength detectable by the reader.

33. The data storage medium of claim 31 wherein the light-sensitive compound absorbs light that, in the absence of the light-sensitive compound, would be detected by the reader.

34. The data storage medium of claim 32 wherein light emission from the compound provides at least a portion of the data obtained when the data storage medium is re-read.

35. The data storage medium of claim 32 wherein the light-sensitive compound is excitable by light emitted by a light source of the reader.

36. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength from about 770 nm to about 830 nm.

37. The data storage medium of claim 36 wherein the light-sensitive compound has an emission wavelength of about 780 nm.

38. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength from about 630 nm to about 650 nm.

39. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength of about 530 nm.

40. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength in the near infrared range.

41. The data storage medium of claim 31 wherein the compound is luminescent.

42. The data storage medium of claim 31 wherein the compound is phosphorescent.

43. The data storage medium of claim 31 wherein the compound has an emission wavelength of about 780 nm, or about 530 nm, or both.

44. The data storage medium of claim 27 wherein the optical recording medium is selected from the group consisting of CD, CD-Audio, CD-ROM, CD-G, CD-i, CD-MO, CD-R, CD-RW, DVD, DVD-5, DVD-9, DVD-10, DVD-18, DVD-ROM and any optical storage medium.

45. The data storage medium of claim 31 wherein the compound is a cyanine compound.

46. The data storage medium of claim 31 wherein the compound is selected from the group consisting of indodicarbocyanines, benzindodicarbocyanines and hybrids thereof.

47. An optical disk comprising a substrate having one or more information pits and land thereon readable as digital data bits by an optical reader, and a fluorescent material positioned over one or more of said information pits and land.

48. The disk of claim 47 wherein the fluorescent material has an emission wavelength at a wavelength detectable by the reader.

49. The disk of claim 47 wherein light emission from the fluorescent material provides at least a portion of the data obtained when the disk is read.

50. The disk of claim 47 wherein the fluorescent material is excitable by light emitted by a light source of the reader.

51. The disk of claim 47 wherein the disk is selected from the group consisting of CD, CD-Audio, CD-ROM, CD-G, CD-i, CD-MO, CD-R, CD-RW, DVD, DVD-5, DVD-9, DVD-10, DVD-18, DVD-ROM and any optical disk.

52. A method of authenticating optical storage media including data structure, the method comprising:

reading the optical storage media at a locus to obtain a first set of usable data from the data structure at the locus; and

re-reading the optical storage media at the locus to obtain a second set of usable data, wherein the second set of usable data is different from the first set of usable data regardless of the data structure of the optical storage media at the locus.

53. The method of claim 52 wherein reading or re-reading the optical storage media at the locus to obtain data at the locus comprises reading or re-reading the optical storage media at the locus to obtain a data bit.

54. The method of claim 52 wherein reading or re-reading the optical storage media at the locus to obtain data at the locus comprises reading or re-reading the optical storage media at the locus to obtain a data byte.

55. The method of claim 52 wherein reading or re-reading the optical storage media at the locus to obtain data at the locus comprises reading or re-reading the optical storage media at the locus to obtain a data frame.

56. The method of claim 52 wherein reading or re-reading the optical storage media at the locus to obtain data at the locus comprises reading or re-reading the optical storage media at the locus to obtain a data block.

57. The method of claim 52 wherein reading or re-reading the optical storage media at the locus to obtain data at the locus comprises reading or re-reading the optical storage media at the locus to obtain a data sector.

58. The method of claim 52 further comprising re-reading the optical storage media at a second locus.

59. The method of claim 52 wherein the first set of data produces a signal that is inadequate to provide for an intended use of data stored on the medium.

60. The method of claim 59 wherein the second set of usable data produces a signal that is adequate to provide for an intended use of data stored on the medium.

61. The method of claim 52 wherein the second set of usable data comprises at least a portion of a file allocation statement.

62. The method of claim 52 wherein re-reading at the locus occurs within about one second of reading at the locus.

63. The method of claim 62 wherein re-reading at the locus occurs within about ten milliseconds of reading at the locus.

64. The method of claim 63 wherein re-reading at the locus occurs within about one millisecond of reading at the locus.

65. The method of claim 52 further comprising providing the optical storage medium with a light-sensitive compound.

66. The method of claim 65 wherein re-reading at the locus comprises reading a signal from the light-sensitive compound.

67. The method of claim 65 further comprising providing light-sensitive compound in the optical path of the locus and an optical detector.

68. The method of claim 65 wherein the light-sensitive compound has an emission wavelength at a wavelength detectable by an optical reader.

69. The method of claim 65 wherein the light-sensitive compound absorbs light that, in the absence of the light-sensitive compound, would be detected by a reader.

70. The method of claim 68 wherein a light emission from the compound provides at least a portion of the second set of usable data.

71. The method of claim 68 wherein the light-sensitive compound is excitable by light emitted by the optical reader.

72. The method of claim 65 wherein the light-sensitive compound has an emission wavelength from about 770 nm to about 830 nm.

73. The method of claim 72 wherein the light-sensitive compound has an emission wavelength of about 780 nm.

74. The method of claim 65 wherein the light-sensitive compound has an emission wavelength from about 630 nm to about 650 nm.

75. The method of claim 65 wherein the light-sensitive compound has an emission wavelength of about 530 nm.

76. The method of claim 65 wherein the light-sensitive compound has an emission wavelength in the near infrared range.

77. The method of claim 65 wherein the compound is luminescent.

78. The method of claim 65 wherein the compound is phosphorescent.

79. The method of claim 70 wherein the compound is excitable at a wavelength of about 780 nm or about 530 nm.

80. The method of claim 65 wherein the compound has an emission wavelength of about 780 nm, or about 530 nm, or both.

81. The method of claim 65 wherein the light-sensitive compound has an emission wavelength of less than about 848 nm.

82. The method of claim 65 wherein the compound has emission wavelengths of about 780 nm and about 530 nm.

83. The method of claim 52 wherein the optical recording medium is selected from the group consisting of CD, CD-Audio, CD-ROM, CD-G, CD-i, CD-MO, CD-R, CD-RW, DVD, DVD-5, DVD-9, DVD-10, DVD-18, DVD-ROM and any optical recording medium.

84. The method of claim 52 wherein the optical recording medium is a CD.

85. The method of claim 52 wherein the optical recording medium is a CD-ROM.

86. The method of claim 52 wherein the optical recording medium is a DVD.

87. The method of claim 65 wherein the compound is a cyanine compound.

88. The method of claim 65 wherein the compound is selected from the group consisting of indodicarbocyanines, benzindodicarbocyanines and hybrids thereof.

89. The method of claim 65 wherein the compound is an indodicarbocyanine.

90. The method of claim 65 wherein the compound is an benzindodicarbocyanine.

91. The method of claim 65 wherein the compound is a hybrid of an indodicarbocyanine and a benzindodicarbocyanine.

92. An optical disk comprising:

a substrate;

a data track disposed on the substrate, the data track including a first set of usable data; and

a light-sensitive compound disposed on at least a portion of the disk and cooperating with at least a portion of the data track, the light-sensitive compound being excitable with a suitable stimulus to produce a second set of usable data that is different from the first set of usable data regardless of the first set of usable data in the data track.

93. The disk of claim 92 wherein the data track is injection molded.

94. The disk of claim 92 wherein the data track is formed via a recording dye.

95. The disk of claim 92 wherein at least a portion of the light-sensitive compound is active.

96. The disk of claim 92 wherein at least a portion of the light-sensitive compound is phosphorescent.

97. The disk of claim 92 wherein at least a portion of the light-sensitive compound is fluorescent.

98. The disk of claim 92 wherein at least a portion of the light-sensitive compound is excitable by a light source emitting light at a wavelength between about 770 and about 830 nm.

99. The disk of claim 92 wherein at least a portion of the light-sensitive compound is excitable by a light source emitting light at a wavelength between about 630 and about 650 nm.

100. The disk of claim 92 wherein the light-sensitive compound is excitable by a light source emitting light at a wavelength between about 780 nm and by a light source emitting at about 530 nm.

101. The disk of claim 92 wherein at least a portion of the light-sensitive compound is adapted to emit at 780 nm.

102. The disk of claim 92 wherein at least a portion of the light-sensitive compound is adapted to emit at 530 nm.

103. The disk of claim 92 wherein at least a portion of the light-sensitive compound is adapted to emit at both about 780 nm and about 530 nm.

104. The disk of claim 92 wherein the light-sensitive compound comprises a cyanine compound.

105. The disk of claim 92 wherein the light-sensitive compound comprises indodicarbocyanines.

106. The disk of claim 92 wherein the light-sensitive compound is benzindodicarbocyanines.

107. The disk of claim 92 wherein the light-sensitive compound is a hybrid of indodicarbocyanines and benzindodicarbocyanines.

108. The disk of claim 92 wherein a portion of the light-sensitive compound is adapted to be selectively activated.

109. The disk of claim 108 wherein the light-sensitive compound is activated by crosslinking.

110. The disk of claim 108 wherein the light-sensitive compound is activated by laser activation.

111. The disk of claim 108 wherein the light-sensitive compound is activated to provide at least a portion of a file allocation statement.

112. The disk of claim 92 wherein the data track includes instructions to re-read a locus on the disk.

113. The disk of claim 112 wherein activated light-sensitive compound is disposed over at least a portion of the locus.

114. The disk of claim 113 wherein the activated light-sensitive compound is a delayed luminescent or phosphorescent compound.

115. The disk of claim 114 wherein the activated light-sensitive compound is interpretable by a reader to provide a response different from that provided by the data track.

116. The disk of claim 112 wherein the data track includes instructions to continue accessing data on the disk based on the first and second sets of usable data being different.

117. The disk of claim 92 wherein the light-sensitive compound is disposed on the disk by spin coating.

118. The disk of claim 92 wherein the light-sensitive compound is less than about 120 nm in thickness.

119. The disk of claim 118 wherein the light-sensitive compound is less than about 10 nm in thickness.

120. The disk of claim 119 wherein the light-sensitive compound is less than about 1 nm in thickness.

121. A method of treating an optical storage medium comprising:

recording a first set of usable data on an optical storage medium;

applying a light-sensitive compound to the optical storage medium at a location on the optical storage medium so that the light-sensitive compound may cooperate with the first set of usable data; and

selectively activating at least a portion of the light-sensitive compound, wherein, in the activated state, the light-sensitive compound allows reading of the first set of data and wherein the light-sensitive compound is responsive to excitation to produce a second set of usable data that is different from the first set of usable data.

122. The method of claim 121 wherein the light-sensitive compound is activated by crosslinking.

123. The method of claim 122 wherein the light-sensitive compound is crosslinked by laser activation.

124. An optical recording medium comprising:

data structure having a first set of data; and

means for producing, upon re-reading at least a portion of the optical recording medium having the first set of data, a second set of data that is different from the first set of data regardless of the data structure having the first set of data.

125. The optical recording medium of claim 124 wherein the second set of data is temporary.

126. An optical recording medium comprising a data track formed of at least one of pits and lands representing a first set of usable data, wherein at least a portion of an output of the data track is predictably altered upon re-reading to produce a second set of usable data that is different from the first set of usable data regardless of the formation of the data track .

127. The recording medium of claim 126 wherein the second set of data is temporary.

128. The optical recording medium of claim 126 wherein the medium comprises a CD.

129. The optical recording medium of claim 126 wherein the medium comprises a DVD.

130. The optical recording medium of claim 126 further comprising a light sensitive light-sensitive compound.

131. A method of authenticating an optical storage medium, the medium having a first plane including data and a second plane having a light-sensitive compound, the method comprising:

reading data from the first plane on the optical storage medium;

exciting the light-sensitive compound in a second plane on the optical storage medium; and

reading data from the second plane of the optical storage medium.

132. The method of claim 131 comprising instructing a reader to alter a focal length of a laser.

133. The method of claim 9 wherein re-reading at the locus occurs within an amount of time required for the light-sensitive compound to emit light.

134. The method of claim 65 wherein re-reading at the locus occurs within an amount of time required for the light-sensitive compound to emit light.

135. The method of claim 9 wherein the light-sensitive compound has an emission wavelength of less than about 848 nm.

136. The data storage medium of claim 31 wherein the light-sensitive compound has an emission wavelength of less than about 848 nm.

137. The disk of claim 92 wherein at least a portion of the light-sensitive compound is adapted to emit at a wavelength of less than about 848 nm.

138. The disk of claim 112 wherein activated light-sensitive compound is disposed under at least a portion of the locus.

139. The disk of claim 47 wherein activated light-sensitive compound is disposed under at least a portion of the locus.

140. The disk of claim 92 wherein the light-sensitive compound is less than about 160 nm in thickness.

141. A data storage medium comprising:

a structure adapted to support data so that the data may be optically read; and

a material disposed on or in the structure, wherein the material is adapted to be altered between at least two states to affect a reading of the structure, the material requiring an input signal to change from a first state to a second state, and not requiring an input signal to change from the second state to the first state, wherein the first state is a state in which reading of the data supported by the data structure is not affected.

142. The storage medium of claim 141, wherein the material is a light sensitive material.

143. The storage medium of claim 141, wherein the second state is a state in which reading of the data supported by the data structure is affected.

144. The storage medium of claim 141, wherein the input signal is electromagnetic radiation.

145. The storage medium of claim 141, wherein the structure is an optical disk substrate.

146. The storage medium of claim 141, wherein the material is a cyanine dye.

147. The storage medium of claim 141, wherein the material has a delay time after which the material changes from the first state to the second state after receiving the input signal.

148. The storage medium of claim 147, wherein the delay time is less than an a time required to read data supported by the structure using oversampling.

149. The storage medium of claim 147, wherein the delay time is greater than an a time required to read data supported by the structure using oversampling.

150. The storage medium of claim 141, wherein the material has a persistence during which the material remains in the second state before changing to the first state.

151. The storage medium of claim 141, wherein the material is positioned in a plurality of discrete areas of the structure.

152. The storage medium of claim 151, wherein the at least one of the position of the discrete areas, a delay time of the material and a persistence of the material represent a code.

153. The storage medium of claim 152, wherein the code may be used to at least one of authenticate the structure, decrypt data supported by the structure, correct data read from the structure, and provide a watermark in data copied from the structure.

154. The storage medium of claim 151, wherein the material is positioned in a plurality of unique discrete areas compared to other storage media in a group.

155. The storage medium of claim 141, wherein the material is temporary such that the material is not detectable in one of the first and second state after a certain amount of time or a number of times that the material is exposed to the input signal.

156. The storage medium of claim 141, wherein the material is disposed at different depths at different locations in the structure.

157. The storage medium of claim 141, wherein the material is used to prevent unauthorized access to data supported by the structure.

158. The storage medium of claim 157, wherein the structure supports data that is freely accessible, and supports data that may be accessed only if the material is detected.

159. An optical recording medium comprising:

a substrate;

a recording portion on the substrate on which data can be recorded and from which data can be read by a reader; and

an authentication material on the substrate, distinct from the recording portion, wherein the authentication material is capable of providing a changing response that can be read by the reader regardless of the data on the recording portion.

160. The optical recording medium of claim 159, wherein the authentication material is a light sensitive material adapted to be altered between at least two states to affect a reading of the structure, the material requiring an input signal to change from a first state to a second state, and not requiring an input signal to change from the second state to the first state.

161. An optical recording medium comprising:

a substrate;

a data recording layer on the substrate; and

a temporary material disposed on at least a portion of the substrate wherein the temporary material provides information that allows a portion of data on the recording layer to be accessed for its intended purpose and wherein the temporary material is arranged to provide readable data.

162. The optical recording medium of claim 161, wherein the temporary material can be decomposed by exposure to a light source.

163. The optical recording medium of claim 161, wherein the temporary material can be decomposed over time.

164. The optical recording medium of claim 161, wherein the temporary material can decompose to such an extent that the portion of the data on the recording layer may no longer be accessed for its intended purpose.

165. A method of verifying the authenticity of an optical storage medium, comprising:

reading at least one locus on the optical medium to obtain a first response;

reading the at least one locus again to obtain a second response different from the first response regardless of the first response; and

using the second response.

166. The method of claim 165, further comprising:

inputting an identification string that is used to determine the at least one locus.

167. The method of claim 165, further comprising:

determining that the optical medium is authentic if the first and second responses are different.

168. The method of claim 165, wherein the step of reading at least one locus comprises:

reading a plurality of loci on the medium in a specified order.

169. A method of making an optical recording medium, comprising:

forming a recording layer on a substrate to support data; and

fixing an authentication material to at least one portion of the substrate, the authentication material adapted to provide a changing response when exposed to an input signal regardless of the data in the recording layer on the substrate.

170. The method of claim 169, wherein the authentication material is fixed in a pattern on the substrate.

171. The method of claim 169, wherein the authentication material is fixed to the substrate after forming the recording layer.

172. A method of transferring data, comprising:

receiving a request for data to be transmitted to a requestor;

receiving a representation of a pattern of material on a storage medium onto which data is to be recorded, the material adapted to be altered between at least two states to affect a reading of the structure;

adjusting data to be transmitted based on the representation of the pattern of material; and

transmitting the adjusted data to the requestor.

173. The method of claim 172, wherein the step of adjusting data comprises:

adjusting the data so that the adjusted data may not be used for its intended purpose unless the data is stored on the storage medium.

174. The method of claim 172, wherein the data includes one of a DVD movie, an audio file and software.

175. The method of claim 172, wherein the step of adjusting data comprises:

adjusting the data so that the adjusted data includes inborn errors that are corrected by using the material on the storage medium.

176. The method of claim 172, wherein the pattern of material is unique to the storage medium compared to other storage media in a group.

177. A method of providing to access protected data, comprising:

sending a first set of data from a source to a target; and

providing a second set of data on an optical storage medium wherein the second set of data is recorded, at least in part, by fixing a pattern of at least one light sensitive material on the optical medium, and wherein the second set of data is necessary to use the first set of data for its intended purpose.

178. The method of claim 177, wherein the at least one light sensitive material is fixed in a pattern that is unique to the storage medium.

179. An optical recording medium comprising:

a substrate including data; and

an authentication mark associated with the data comprising a pattern of light sensitive material, wherein the light sensitive material is adapted to be altered between at least two states to affect the reading of the data.

180. A method of data encryption, comprising:

receiving a request for transfer of data; and

transferring an encrypted data set from a source to a target wherein the encryption key is at least partially provided based on a pattern of authentication material on an optical storage medium on which the data is to be stored.

181. The storage medium of claim 141, wherein, when the material is the second state, readable data is generated.

182. The storage medium of claim 181, wherein the material is temporary such that, after a certain amount of time, no readable data may be generated by the material.

183. A data storage medium comprising:

a structure adapted to support data so that the data may be optically read; and

a material disposed on or in the structure, wherein the material is adapted to be altered between at least two states to affect a reading of the structure, the material requiring an input signal to change from a first state to a second state, and not requiring an input signal to change from the second state to the first state, wherein, when the material is the second state, readable data is generated by the material and wherein the material is temporary such that the material is not detectable in one of the first and second state after a certain amount of time or a number of times that the material is exposed to the input signal.

184. The storage medium of claim 183, wherein the material is a light sensitive material.

185. The storage medium of claim 183, wherein the input signal is electromagnetic radiation.

186. The storage medium of claim 183, wherein the structure is an optical disk substrate.

187. The storage medium of claim 183, wherein the material is a cyanine dye.

188. The storage medium of claim 183, wherein the material has a delay time after which the material changes from the first state to the second state after receiving the input signal.

189. The storage medium of claim 185, wherein the delay time is less than an a time required to read data supported by the structure using oversampling.

190. The storage medium of claim 185, wherein the delay time is greater than an a time required to read data supported by the structure using oversampling.

191. The storage medium of claim 183, wherein the material has a persistence during which the material remains in the second state before changing to the first state.

192. The storage medium of claim 183, wherein the material is positioned in a plurality of discrete areas of the structure.

193. The storage medium of claim 192, wherein the at least one of the position of the discrete areas, a delay time of the material and a persistence of the material represent a code.

194. The storage medium of claim 193, wherein the code may be used to at least one of authenticate the structure, decrypt data supported by the structure, correct data read from the structure, and provide a watermark in data copied from the structure.

195. The storage medium of claim 192, wherein the material is positioned in a plurality of unique discrete areas compared to other storage media in a group.

196. The storage medium of claim 183, wherein the material is disposed at different depths at different locations in the structure.

197. The storage medium of claim 183, wherein the material is used to prevent unauthorized access to data supported by the structure.

198. The storage medium of claim 197, wherein the structure supports data that is freely accessible, and supports data that may be accessed only if the material is detected.

199. The method of claim 165, further comprising using the first response.

200. The method of claim 1 wherein re-reading at the locus occurs within about one millisecond and about 20 minutes.

201. The method of claim 9 wherein the light-sensitive compound has one or more emission wavelengths, each ranging between about 400 nm and about 900 nm.

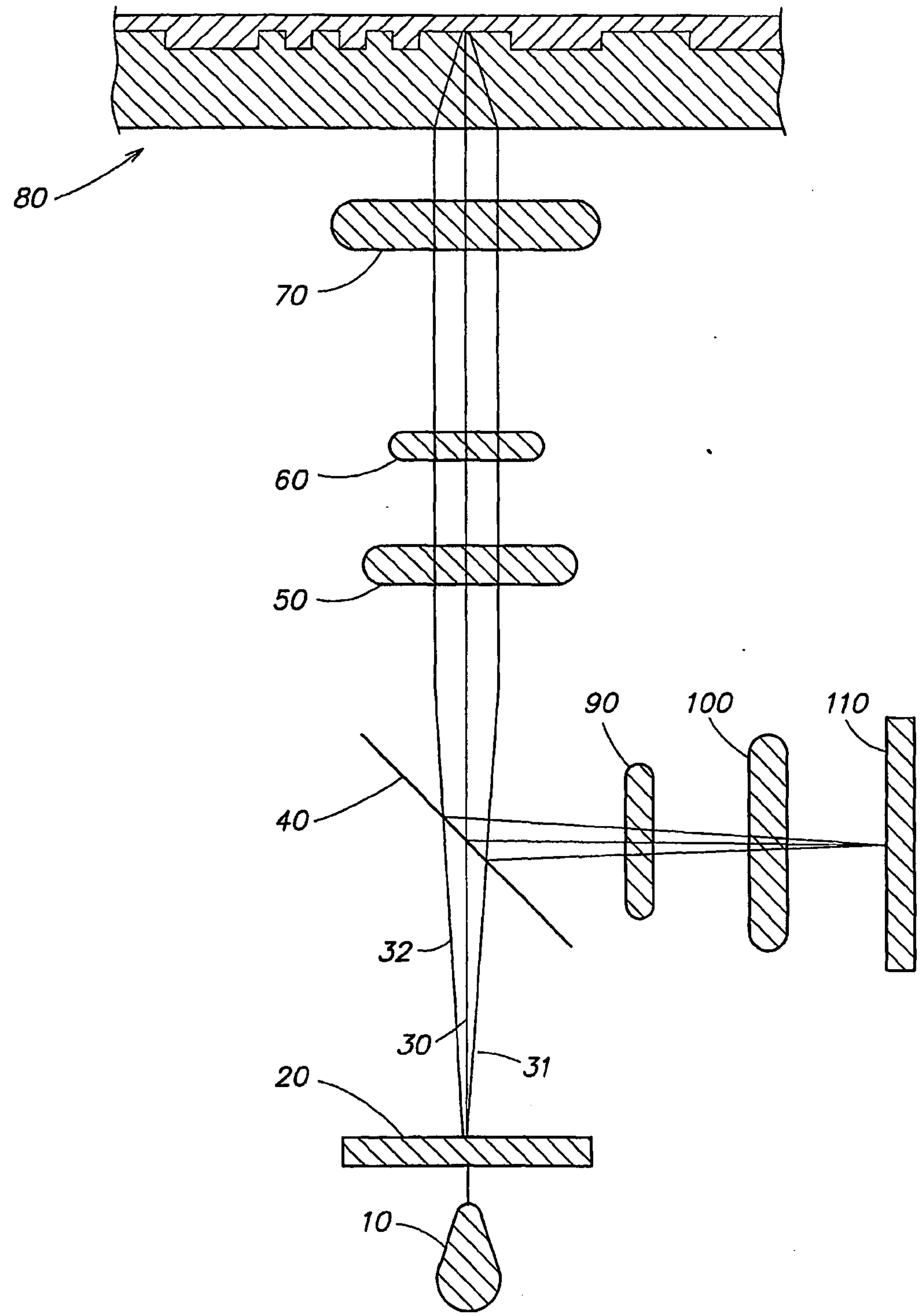


FIG. 1

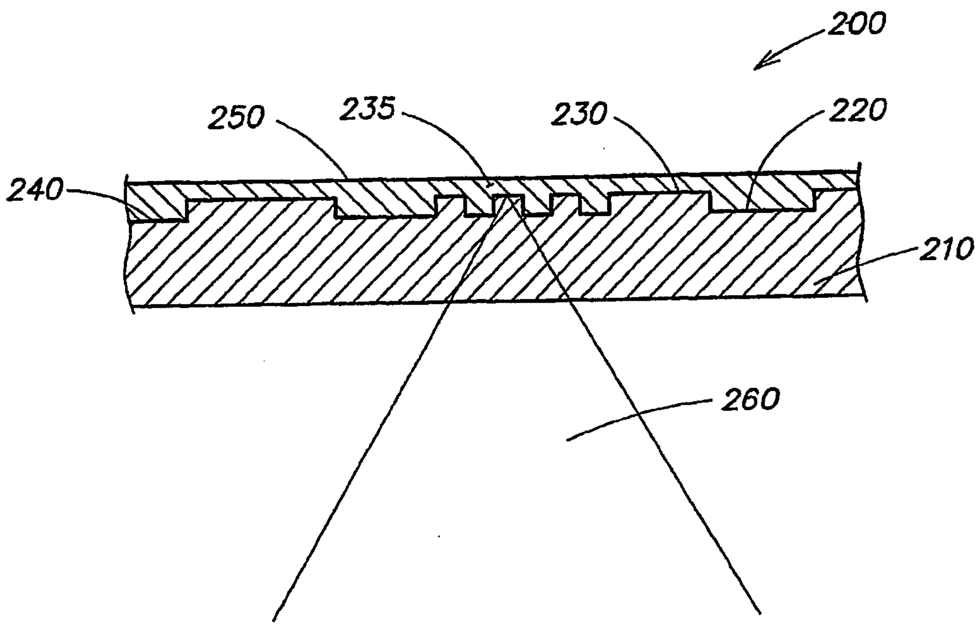
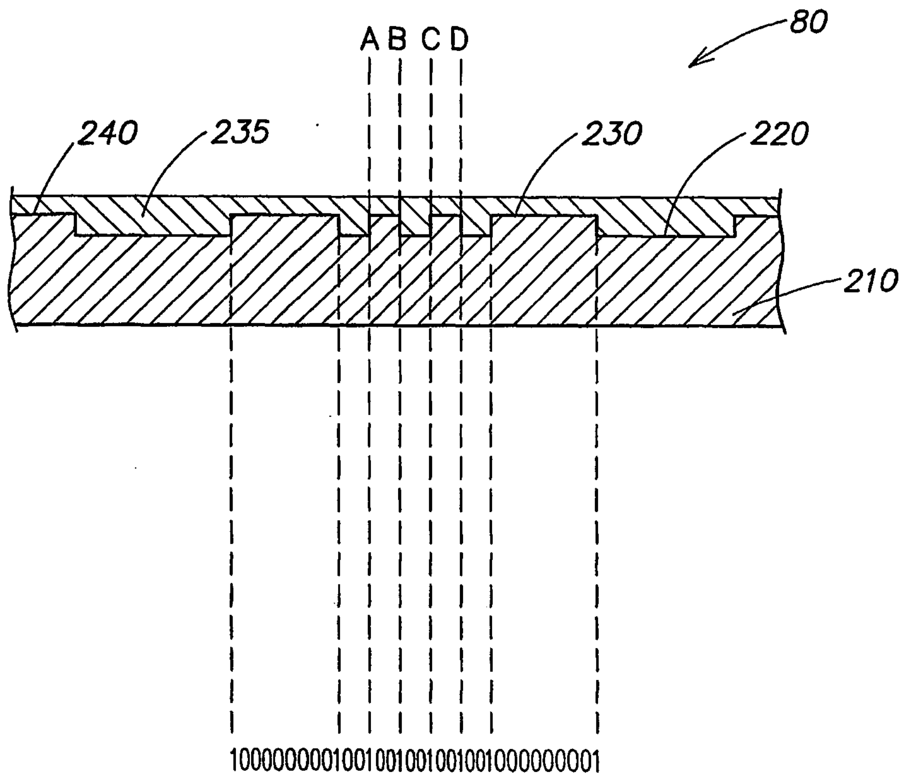


FIG. 2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230
220
210
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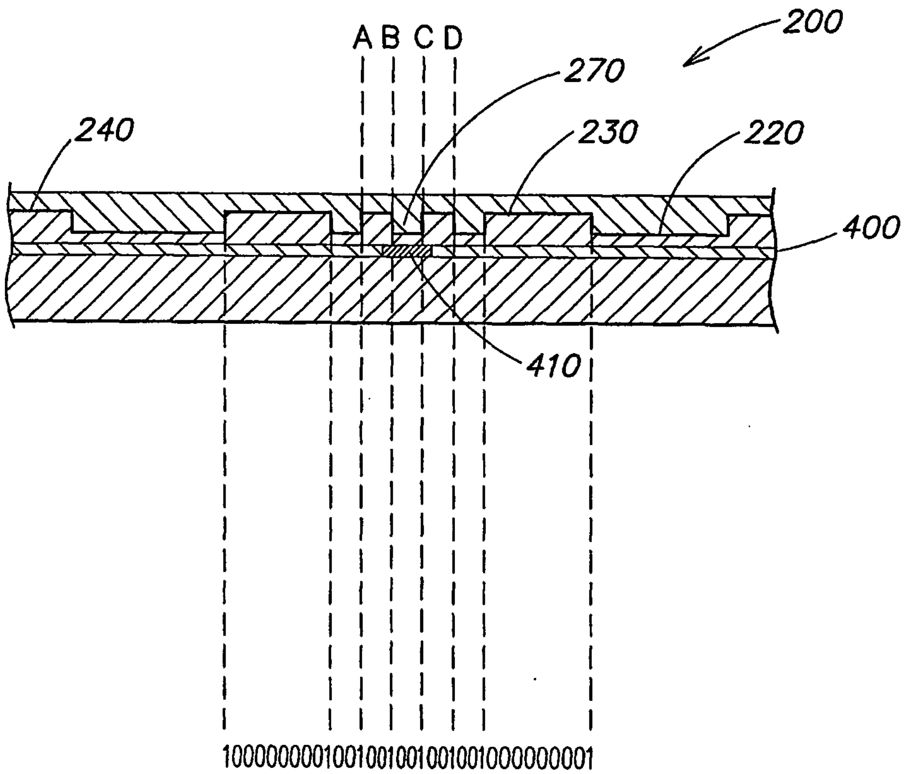
FIG. 3



200
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240
230
220
400
410
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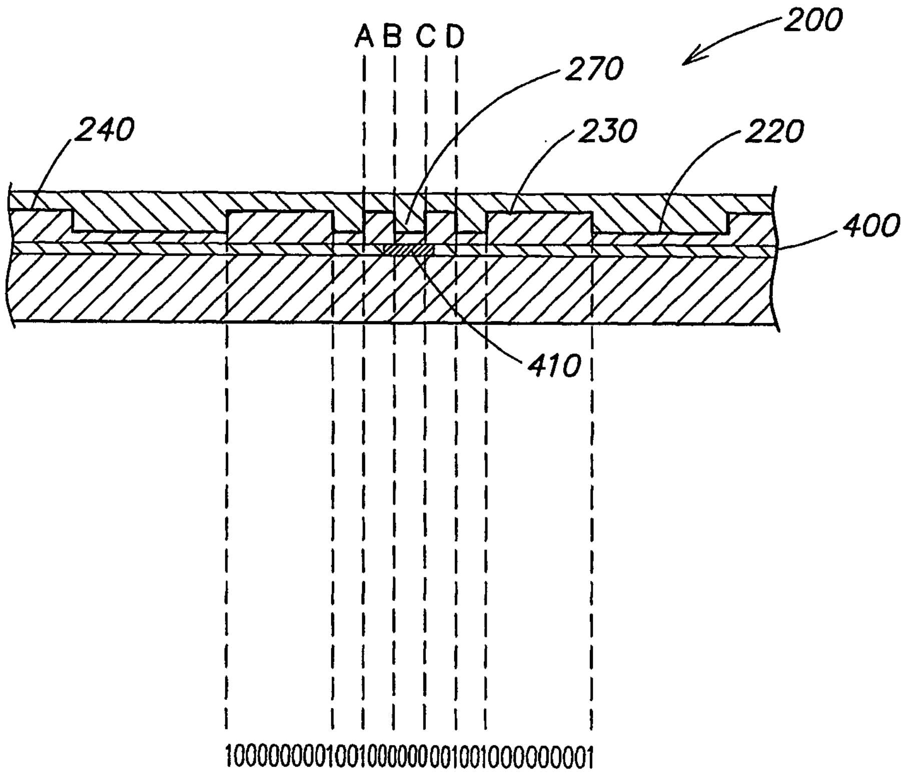
FIG. 4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A B C D
270
240
230
220
400
410
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FIG. 5

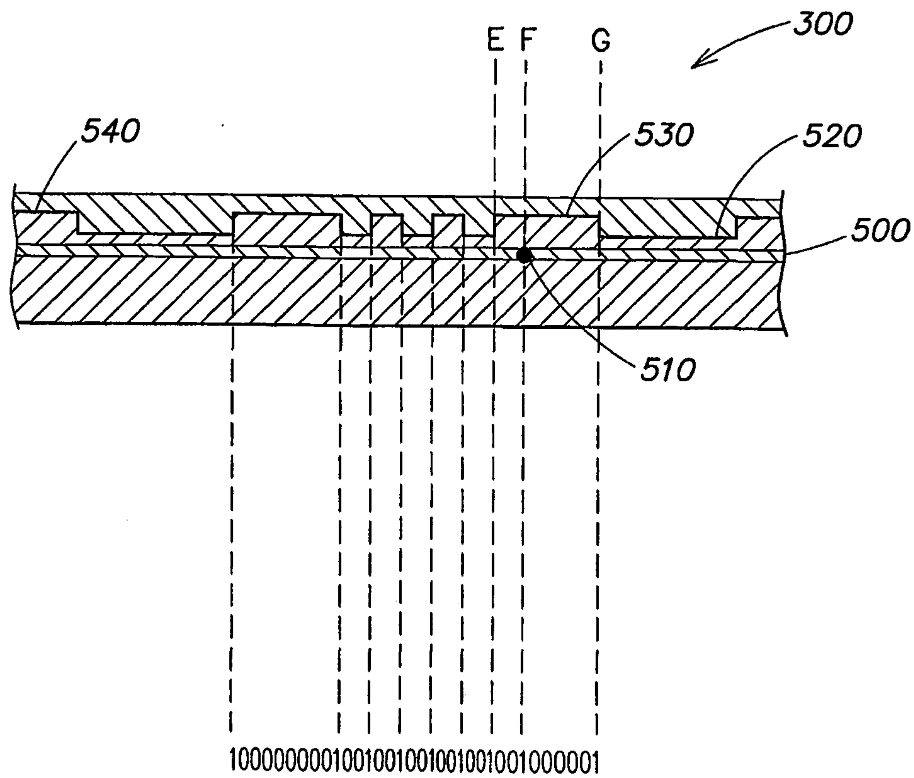
300
E
F
G
540
530
520
500
510
1000000001001001001001001001000001

FIG. 6

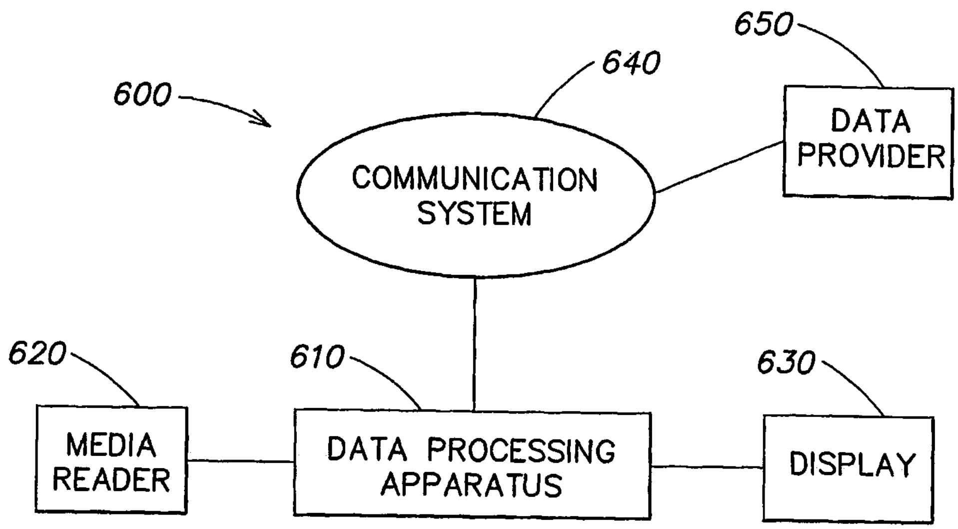
600
640
650
COMMUNICATION SYSTEM
DATA PROVIDER
620
610
630
MEDIA READER
DATA PROCESSING APPARATUS
DISPLAY

FIG. 7

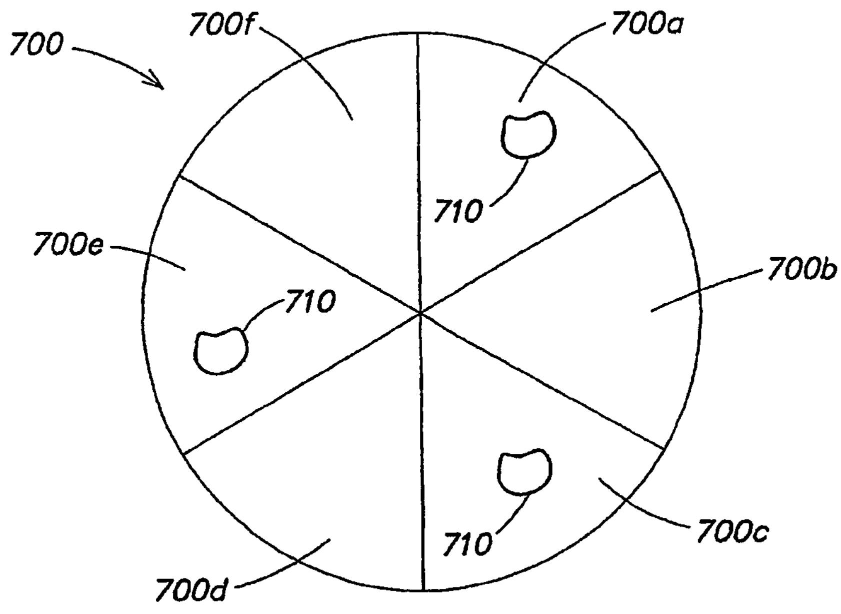
700
700f
700a
710
700e
700b
710
710
700c
700d

FIG. 8

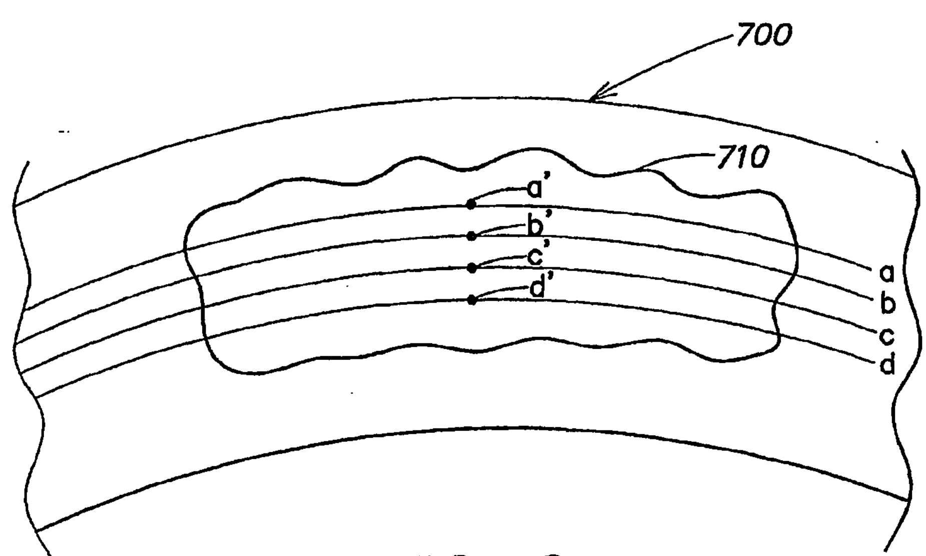
700
710
a'
b'
c'
d'
a
b
c
d

FIG. 9